STEEL FRAMING FOR SMALL RESIDENCES

CARNEGIE STEEL COMPANY
SUBSIDIARY OF UNITED STATES STEEL CORPORATION
PITTSBURGH, PENNSYLVANIA

A. I. A. FILE No. 13

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FOR

SMALL RESIDENCES

Printed in U. S. A.

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A Guidebook for Architects and Builders

Published by
Subsidiary Companies of
UNITED STATES STEEL CORPORATION

PRICE FIFTY CENTS

SUBSIDIARY COMPANIES
OF
UNITED STATES STEEL CORPORATION

(MANUFACTURING OR DISTRIBUTING MATERIAL USED IN RESIDENCE CONSTRUCTION)

AMERICAN BRIDGE COMPANY

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For Steel Framing Material, see Page 33
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STEEL FRAMING FOR SMALL RESIDENCES

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FOREWORD

THE PRESENT BOOKLET is the outcome of a detailed survey recently made by a trade research committee drawn from Subsidiary Companies of United States Steel Corporation for the purpose of investigating the potential demand for steel in residence construction. Nearly one hundred different systems of construction were studied. A number of the residences built in accordance with these systems were inspected by representatives of the committee. The following conclusions were indicated:

(1) There exists a wide spread interest in steel framed residences. The principal demand is for small one and two family houses of individual design.

(2) Steel can be advantageously used in the construction of residences of any architectural style or arrangement to provide a frame that will not shrink, is inherently non-combustible, sanitary and rigid, resists the destructive attack of insects, and can readily be made permanent.

(3) Certain new practices can be employed with safety and economy in the design of the steel framework for small residences along lines not contemplated in current engineering handbooks.

(4) With the aid of suitable information the steel framework can be designed by architects as readily as in the case of older forms of construction.

(5) The details of the steelwork can be developed to advantage in cooperation with the personnel of a fabricating shop located in the vicinity of each job.

(6) The fabrication and erection requirements are simple and are well suited to the equipment of the smaller structural or sheet metal shops.

This booklet is intended to assist in the application of steel to the residential field. It specifically aims to provide architects, builders and fabricators with available information on the safe, practical and economic use of steel in the framework of small residences. The new practices are explained and subjected to rule, and the manner in which they can be applied is exemplified. Rules for proportioning individual members are supplemented by lists of suitable sections, including two new light weight beam sections, and by tables that will facilitate their use. In order to simplify their application to small residences the rules are expressed in the form of conventions which would not necessarily be valid beyond the limits of the field in question.

A five-fold classification of steel wall framing systems is presented depending on the manner in which the steel members are employed. One residence in each of the five classes is illustrated by means of annotated photographs and detailed sketches. The examples were selected from the standpoint of their suitability to depict the respective class features. Their presentation in this booklet should not be construed as indicating superiority over many other meritorious examples in each class, whose inclusion was not permitted by considerations of space. The construction used in the residences illustrated will doubtless suggest other advantageous ways of utilizing steel in this field.

The primary aim of the booklet is to assist those desiring to use steel in houses of individual design, but its contents may also be helpful to those who favor systems of construction that contemplate multiple production methods.

While the text is restricted to the use of steel for framing purposes many collateral uses are indicated on pages 52 to 54 for which the diversified products of the Subsidiary Manufacturing Companies of United States Steel Corporation are particularly suitable.

Use of the term "Kip." Throughout this booklet loads and unit stresses are expressed in Kips. The term **kip** (abbreviated from kilo-pound) has been extensively used in technical literature to designate **one thousand pounds** and is employed here as being terse and convenient.

Basis of Design of the Structural Framework

Current engineering handbooks on structural steel, such as the Carnegie-Illinois Pocket Companion or the manual of the American Institute of Steel Construction, are not entirely adequate for use in connection with small residences. These books were intended to apply to a class of construction, such as tier buildings, wherein the dead loads are comparatively large, and whose structural steel members must be self-sufficient under all circumstances.

In residences the conditions are different. Outstanding is the fact that the dead load is proportionately less and that under some circumstances the steel members may properly be assumed to be strengthened by other enveloping materials*. The steel frame of a residence designed in accordance with the engineering handbooks would be perfectly safe but the resulting construction, especially in the case of small residences, would be so heavy as to form a commercial handicap which experience indicates may not be necessary. A further difference between tier building and residence design is the extent to which short cuts are permissible. When designing a tier building it is the correct practice to compute all load reactions separately, but in residence construction many loading conditions may be averaged without affecting the framing sizes that should be used. Architects and builders who have had experience with wood framing will readily recognize those cases in which the more rapid method of averaging may be employed with safety. The manner in which advantage can be taken of the special conditions obtaining in any system of residence construction is explained in detail in the following pages.

Columns and Studs. In residence construction it is customary to apply the term column to any main vertical compression member that supports a considerable floor, roof or wall area, or a large concentrated load. The term stud is applied to the less individually important vertical members which are spaced at intervals in a wall or partition, and which are usually subject to bending in one direction in addition to axial compression.

The basis of design for residential columns does not differ from that given in the engineering handbooks. Steel members composed of cylindrical pipe or wide flange H sections will prove efficient for the heavier loadings. The symmetrical section of a steel pipe column combines maximum strength per pound of metal with a neat appearance. When no lateral connections are required, as in a member extending through only one story, the pipe form of column is especially suitable.

In many successful applications of steel to residential framing the sections used as studs, while reasonably deep on their major axis, are quite narrow on their minor axis. Rolled steel channels and built-up members, 8 to 10 feet long and 3 or 4 inches deep, but only 1½ inches wide, are common practice. After completion of the residence the unbraced length of the stud is reduced by anchoring it at intermediate points along its length to the enveloping wall materials, but during construction the unbraced length of these studs may give a slenderness ratio* ranging up to 300. The handbooks give no design data for members whose slenderness ratio exceeds 200.

In order to provide for this condition the scope of the column formula of the American Institute of Steel Construction** has been extended to give allowable unit stresses for values of l/r from 200 to 300 in accordance with the formula for a straight line tangential to the A. I. S. C. curve at $l/r = 200$. After a slight rounding the expression becomes: $f = 13{,}300 - 38.5(l/r)$. The composite curve is

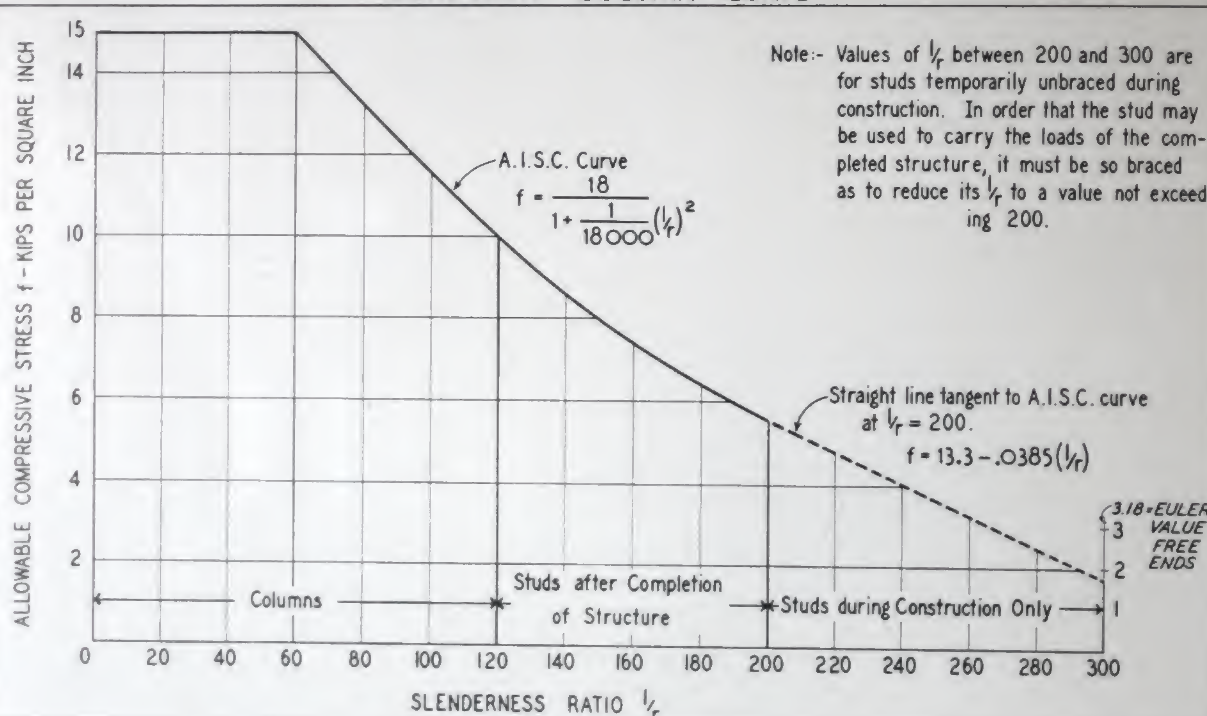
*In localities subject to earthquakes the extent to which the envelope may be relied upon for stiffening purposes should be considered as part of the proper basis of design for special systems of steel framing to resist earthquake shock. The design of framing to withstand the effect of earthquakes is beyond the scope of the present booklet.

*l/r = ratio of unbraced length to radius of gyration in question.

** $$f = \frac{18{,}000}{1 + \frac{1}{18{,}000}(l/r)^2}$$ Where f is the allowable stress in lb. per sq. in.

shown in the accompanying figure with f expressed in kips. At $l/r = 300$ the allowable unit stress shows a factor of safety of 1.82 when referred to the Euler formula for a free ended column. It must be emphasized that values higher than 200 should be limited to temporary conditions during construction, as stipulated in the figure and on pages 46 and 47.

COMPOSITE COLUMN CURVE



A second condition in structural practice that is not contemplated in the engineering handbooks is that in residences whose walls (enveloping a stud) are composed of an adequate thickness of well bonded, substantial material, such as brick, hollow tile, stone, concrete or well backed steel panels, it appears entirely proper in the design of the stud to take cognizance of the stiffening action provided by the enveloping material. In previous types of building construction this stiffening effect, while acknowledged to be present, has usually been disregarded in the design of the structural steel framework.

In residences, due to relatively lighter loads, and the desire for the greatest economy consistent with safety, the stiffening effect of the envelope may be advantageously utilized. During construction of the frame this effect does not come into play. Consequently at that stage the studs must be stiff enough to withstand the moderate loads resulting from the weight of the superimposed steel parts and any temporary erection conditions. It is desirable to add one kip (1000 lb.) per stud for accidental erection loading. When subjected to the greater loads in the finished structure, however, anchorage to the envelope permits the studs to be computed as performing a double function.

First, at right angles to the wall, the studs stiffen the enveloping material, whose thickness in the average residence seldom exceeds 4 inches. This action is recognized by the usual specification which requires that masonry veneer shall be anchored to the framework at intervals equivalent to every fifth course of brickwork. A practical rule for dimensioning the studs to meet this condition is presented on page 7.

The more important function of the studs, however, is to support the weight of the floor and upper wall filling material, as well as the live load on the completed house. The new feature here is that the enveloping material, while stiffened by the studs transversely to the wall, is in turn used to stiffen

the studs in a plane parallel to the wall. Rigid and adequate anchorage will insure maximum efficiency when the anchors are spaced at such intervals as will make the working strength of the stud equal on both its major and minor axes.

The importance of straightness, especially in long slim studs, should be kept in mind. Care must be taken during erection to avoid such slight bends or kinks as may invite local buckling under loads below the designed capacity of the stud.

Horizontal Forces. The proper bracing of a framed house is of great importance. During construction the steel framing as a whole should be sway braced against distortion due to wind or accidental forces. A horizontal load of 10 lb. per sq. ft. on exposed surfaces* should be provided for.

This may be done by the use of long diagonal guy wires or rods in vertical planes connecting rigid studs to rigid girts at all salient and reentrant corners. Diagonal knee bracing may be used, but it should be noted that its efficiency is limited by the transverse stiffness of the studs and girts to which the braces are connected. In some cases sufficient stability is secured by the use of temporary diagonal planks. When guys are used they can be arranged so as to clear all openings, and if this is done they may be left permanently in place. If their later removal is contemplated they may be located without reference to the openings.

In some cases a steel stair may be arranged so that its sloping stringers provide efficient sway bracing for a part of the residence. If the stair is erected prior to the placing of the floor finish, adequate provision for the height of the finish should, of course, be made.

After the residence is completed, the filling material of both walls and floors affords added stiffness to the assembled structure. In a number of observed instances the framework, which during erection could be noticeably swayed by pressure against the second story studs, became quite rigid after it was enclosed.

As pointed out on page 6, exterior wall studs, in addition to supporting vertical loads, are also called upon to brace the walls against horizontal pressures. An analysis of a number of residences whose steel framing behaved satisfactorily indicated that a stud will afford the required stiffness if it is designed to withstand a uniformly distributed horizontal load of 10 lb. per square foot of wall surface.

If, in strict conformity with engineering practice, this bending stress were to be combined with the compressive stress due to vertical loading, the computation for the stud would be somewhat complicated*. This procedure, however, is not required when the stud section is symmetrical as is the case when I-beams or channels are used.

A study of actual applications indicates that practical requirements in the field of small residence construction (where the stud length rarely exceeds 10 feet, and the spacing averages 4 feet or less) may be met in a simpler manner by the following rule:

(1) Use a stud having a symmetrical section (such as an I-beam or channel) not less than 3 inches deep and having a solid web or adequate lacing.

(2) To the compressive load add a bending factor F of 1.3 kips (1300 lb.) for each foot of horizontal wall surface braced by the stud in question.

Examples showing the selection of studs by this method are given on pages 15 and 47.

Beams and Joists. In the design of floors, conditions in residence construction differ from those prevailing in tier buildings in two important respects:

(1) The demand for a minimum depth of floor is even more insistent.

(2) The live load to be provided for usually exceeds the dead load.

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*This pressure, equivalent to a wind velocity of 50 miles per hour, is that required by ce tain building codes for structures less than 40 ft. in height.

*One ultra-safe conventional method would be to determine the compressive load F due to bending stress as follows:

$$F = \frac{15\,A\,B\,L^2}{S} \text{ where } \begin{cases} A = \text{area of stud} \\ B = \text{stud spacing, in feet} \\ L = \text{stud length, in feet} \\ S = \text{section modulus of stud} \end{cases}$$

This method requires, first, that a stud be tentatively selected on the basis of the direct compressive load. Then with its geometrical properties known, the value of F would be computed and added to the compressive load. The total load would then have to be checked back to see whether it is within the allowable capacity of the stud as given in the tables.

The total load is usually small enough to permit the advantageous use of light shallow sections but, in order to avoid the cracking of plastered ceilings, this construction must be accompanied by provision that the live load deflection shall not exceed 1/360 of the span. This deflection requirement is not new, but in the design of residence floors it becomes the controlling feature so often that a special arrangement has been followed in the tabular matter. With the view of facilitating the work of the architect or builder, the tables of safe loads for rolled steel sections used as beams (pages 44 and 45) make it possible, without further computation, to select the most economical beam that will carry the total load without excessive deflection due to the live load.

If it is desired to use open web joists the standard specification published by the Steel Joist Institute will prove helpful. This specification also covers metal lumber joists.

Girts. In tier buildings it is the practice, except in the case of setbacks, to make the vertical wall columns continuous and to break the horizontal floor framework of beams and girders. This is done because tier building columns are usually widely spaced and carry heavy loads. In residence construction the vertical wall studs are placed much closer together and are of light section. In order to provide for an elastic arrangement of door and window openings it is both desirable and feasible to make the studs non-continuous by breaking their length at each floor level. It is then advantageous to dispose the horizontal girt framing (including also sills and eaves plates) in continuous courses along the entire length of each side of the house. This practice permits the girts to:

(1) Tie together the ends of the studs.

(2) Provide a bearing seat for the ends of the joists or rafters.

(3) Transfer the load from the joists or rafters to adjacent studs.

(4) Act as struts to withstand the stress of long diagonal members used as sway bracing.

When designing the steel framework to provide for these functions the following points may be helpful:

Any continuous steel girt adequate to fulfill its other requirements will usually form a suitable tie section. In order to provide a convenient detail for receiving the ends of the connecting members it should have an available horizontal surface, such as the flange of an I-beam or the leg of an angle.

As far as possible each joist or rafter should be spaced so as to come within a few inches of a point directly above the corresponding stud. With this arrangement the bending on the intervening girt is negligible. However, when the respective members are not adjacent (as over a door or window opening), the bending must be provided for. This may be done either by the substitution of a stronger girt section over the opening, or by the insertion of an additional section under the regular one, as was done in the Schwarz Residence illustrated on pages 22 and 23. In all cases the web of the girts should be dimensioned to resist buckling due to the maximum vertical shear. The shear resulting from the uniformly distributed loads tabulated on pages 44 and 45 is not excessive. If a considerable load is concentrated the web value of the selected sections should be ascertained from the Carnegie-Illinois Pocket Companion.

The resistance to bending of double girts (when riveted or welded flange to flange one above the other) is always somewhat greater than the sum of the strengths of the individual members. Where a closer degree of accuracy is desired the combined strength should be computed for each case.

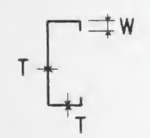
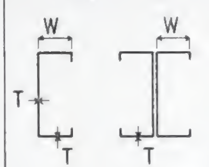
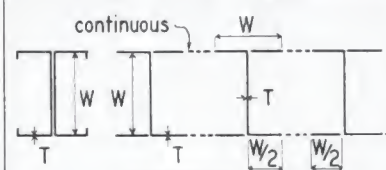
The use of a double girt over wide openings, while theoretically less efficient per pound of material than a single member of the same total depth, is frequently more desirable in practice. It permits the principal girt to remain continuous, and it reduces the variety of sections to be ordered.

Metal Lumber. Some systems of steel frame construction utilize members, popularly called metal lumber, made of thin steel supplied in the form of flat sheets or rolled strip, the members subsequently being shaped by cold bending or rolling, with or without the aid of welding. The use of such members as joists is covered by the standard specification of the Steel Joist Institute.

The employment of sheet steel for other types of framing such as studs, girts, and cellular and panel construction, is quite recent, and the probable behavior of untested sections, whether employed alone as framing or combined with covering, is not known sufficiently well to warrant the formulation at this time of definite rules for their use.

Up to the present very little information has been made available that will permit architects or engineers to prepare even a preliminary design that contemplates the use of new forms of sheet steel as structural members. It is well recognized that large unbraced areas of thin gage material will buckle when subjected to bending and compressive stresses. The strength of such sections can be substantially increased if stiffened by flanging their edges.

One of the most important questions concerns the width of the elements of the section which can be considered effective to resist bending or compressive stress. As a result of a study of representative American and European practice, the following table is offered as a tentative basis on which metal lumber designs may be computed for preliminary purposes. In each case the design should be checked by full size tests before it is adopted for use.

DEGREE OF FIXITY	One Edge Free One Edge Restrained	One Edge Restrained One Edge Fixed	Both Edges Fixed
LOCATION OF EFFECTIVE ELEMENT			
RATIO W/T	10	30	100

TENTATIVE RATIOS OF FLAT WIDTH (W) TO THICKNESS (T) OF ELEMENT
TO BE ASSUMED AS EFFECTIVE IN COMPUTING
THE GEOMETRIC PROPERTIES OF INDIVIDUAL SHEET METAL SECTIONS.

Connections. The steel framing of a residence may be connected by riveting, bolting or welding. The strength values for rivets and bolts given in the Standard Specification for Structural Steel for Buildings of the American Institute of Steel Construction have been widely adopted and seem suitable for residence construction. Welded connections may be made by either a fusion or a resistance process, the resistance method being especially well suited to the shop welding of thin material. Two publications of the American Welding Society, its Code for Fusion Welding and Gas Cutting in Building Construction, and the Report of its Structural Steel Welding Committee, will be found helpful in connection with fusion welding.

Typical Steps in Designing Steel Framing

In order to exemplify the manner in which suitable steel sections for the floor and wall framing may be selected from the tables of safe loads on pages 42 to 51, a detailed description of the application of these tables to a specific residence will now be given. The Schwarz residence depicted on pages 22 and 23 will be considered. For illustrative purposes it will suffice to compute here only the typical framing members. This residence was completed in 1931, before the tables in this booklet were available. Some of its framing members are slightly stronger than would be theoretically required if selected from the tables.

For this house the following loads per square foot of surface are used:

LIVE LOADS

Floors	40 lb.
Walls	(Wind) 10 lb.
Roof	(including Wind) 29 lb.

DEAD LOADS

Floors	
Steel	3 lb.
2″ Haydite or 3″ Hollow Tile	10 lb.
Two coat plaster ceiling	6 lb.
2″ x 4″ Pine Sleepers, 14″ centers	2 lb.
Wood Flooring	4 lb.
	25 lb.
Walls	
Steel	2 lb.
4″ Brick Veneer	49 lb.
2″ Furred Tile	10 lb.
Three Coat Plaster Surface	9 lb.
	70 lb.
Roof	
2″ x 8″ Pine Rafters, 24″ centers	2.4 lb.
⅞″ Wood Sheathing	2.6 lb.
Shingles	3.0 lb.
	8.0 lb.
Partitions	
2″ Hollow Tile, plastered two sides	20 lb.
4″ ditto	25 lb.
6″ ditto	30 lb.

The several steps in the development of the design are illustrated in Figs. 1, 2, 3, 6, 7 and 8. In actual practice a single plan would suffice for the four steps which, for greater clarity, are here shown separately in Figs. 1, 2 and 3.

For this residence the architect and builder adopted a floor construction consisting of steel I-beam joists spaced approximately 4 feet apart, supporting a light concrete or hollow tile slab on the lower flanges of the beams, and wood sleepers on the upper flanges. The wall construction consists of light rolled steel channel and I-beam studs faced with a 4 inch brick veneer on the outside and 2 inch furred hollow tile on the inside. Cross sections of the wall and floor are depicted on page 22.

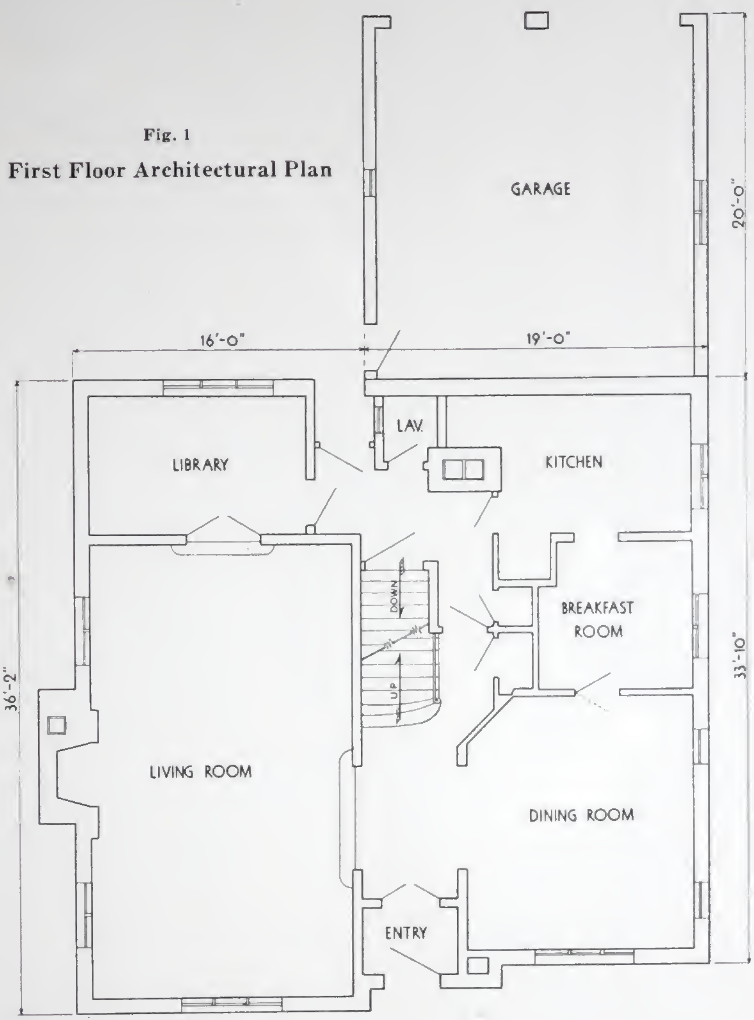
The first floor architectural plan of the house is shown in Fig. 1. The floor of the living room is dropped 10 inches below the level of the other rooms on the first floor. The attached garage, one-story high, is not framed with steel. Its walls were made of 4 inch hollow tile faced with 4 inch brick. Fig. 2 shows the foundation walls which were built up to the proper distance below the finished living room and first floor levels. An interior hollow tile partition in the basement encloses a recreation room immediately beneath the living room.

Locating Steel Floor Framing. The first step is to lay out the sills along the top of the foundation walls (Fig. 2). These members serve to assure a level base for the studs which later are to be attached to them. The determination of the size of the sill should be postponed until after the studs are dimensioned in order that suitable connections may be assured. In this house it was then found that a 3 inch standard steel I-beam (5.7 lb. per ft.) would adequately serve this purpose. The connection details are shown on page 22. Sills A1, A2, and A3, are 10 inches below sills A4 to A7, to provide for the difference in elevation of the living room floor.

In order to provide for the framing around the stairwell and the flues for the incinerator and boiler, two beams, G1 and G2, are located directly under the partitions separating the breakfast room from the dining room and the kitchen, and are supported by three basement columns, C1, C2, and C3. The required size of these members will be determined after the rest of the floor system is laid out.

Fig. 1

First Floor Architectural Plan



The next step is to locate the joist J2 that frames the stairwell. The flanges of this member should clear the opening by at least one inch to permit plastering. Joists J3, J4 and J5 are then spaced at approximately equal distances apart. No waste of material need be incurred due to unavoidable architectural changes. For example, after the beams had been ordered, a shift of 18 inches in the location of the partition between the dining room and the breakfast room was easily provided for in the field by arc-welding the beams end to end into one length, thus making them continuous from front to rear.

The flues are framed with joists J7, and then the library floor joists J8 are located. In the living room it was desired to space the joists J1 as shown. They rest at both ends directly upon the flanges of the I-beam sills. Fig. 4 shows a portion of the steel framing in the floor of the dining room. Throughout the residence all members are arc-welded together as shown in the figure.

Computing Sizes of Joists. With their locations determined, it is now feasible to select the size of the joist beams required to adequately support the floor. In the design of floors it is generally good practice to determine the deepest beam required to support a typical floor area and then to make all the beams of that depth. This practice permits the foundation walls to finish at the same level and all the beams to be flush top and bottom. In some cases it may involve a small amount of excess steel but, if there are many

changes in level, the added cost of labor and materials, notably in the more complicated form work required, usually exceeds the cost of the excess steel. A further advantage in using the same section is the economy obtained and the time saved by ordering the steel material in duplicate or multiple lengths from the warehouse or the fabricator.

In accordance with this practice the size of the critical joist will be determined, and the section selected will be used throughout for all typical floor joists. This joist J1 is located in the first floor at the rear of the living room. Its span is $15'-2''$ and it supports a width of floor equal to one-half the sum of the two adjacent panels, namely $\frac{1}{2}$ $(4'-0'' + 4'-8'') = 4'-4''$. The total uniformly distributed load is 15.16 x 4.33 x 65 = 4270 lb. [4.27 kips], of which the live load is 2.63 kips.

Referring to the table of Allowable Uniform Loads for Sections used as Beams, on page 44, and following down the column for a 16 foot span, (the next above $15'-2''$) it is found that Section B41, a 6 inch special I-beam weighing 10.0 lb. per foot, may be subjected to a total load of 4.4 kips, provided the live load does not exceed 3.0 kips, whereas the next lighter section, a 5 inch I-beam, is not strong enough. However, at the time this residence was built Section B41 was not available, and Section B14, a 6 inch standard I-beam weighing 12.5 lb. per foot was used.

It should be noted that, for maximum economy in weight, it would be possible to use Section C6, a 7 inch channel weighing 9.8 lb. per foot, which is 2.7 lb. per foot lighter than the 6 inch standard I-beam. In this case the I-beam was preferred on account of its lesser depth, its greater lateral stiffness and its more convenient shape.

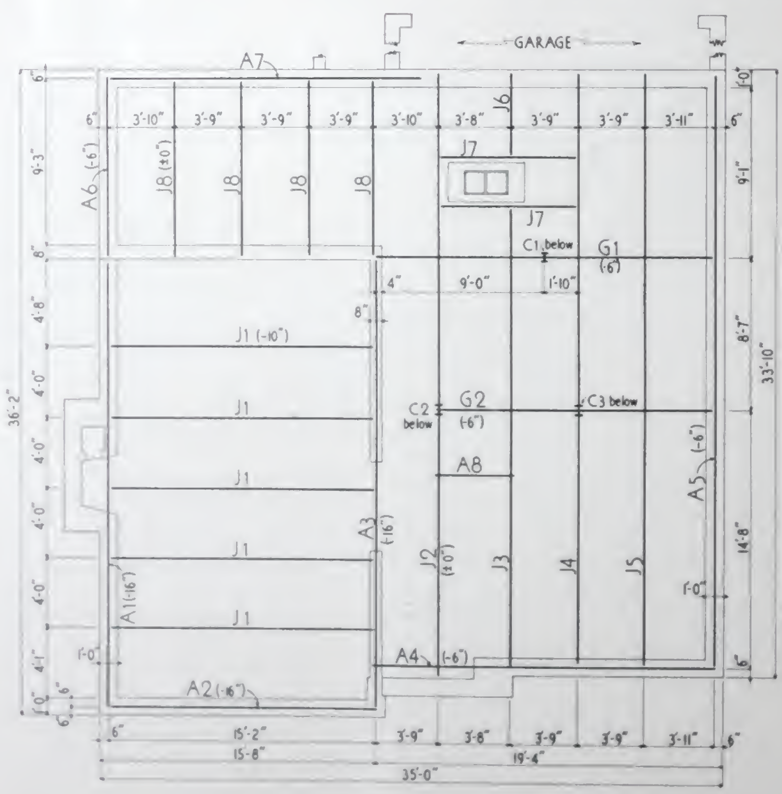


Fig. 2

FIRST STEP—Locating the First Floor Steel Sills and Joists (Elevations are Referred to Top of Joists J2 to J8)

SECOND STEP—Size of Joists Computed as Explained in Text
The Joists Marked J1 to J8 are 6" I-Beams, 12.5 Lb.
The Girder Beams G1 and G2 are 8" I-Beams, 17 Lb.
Girts A1 to A7 are 3" I-Beams, 5.7 Lb., A8 is 3 x 3 x ¼" Angle

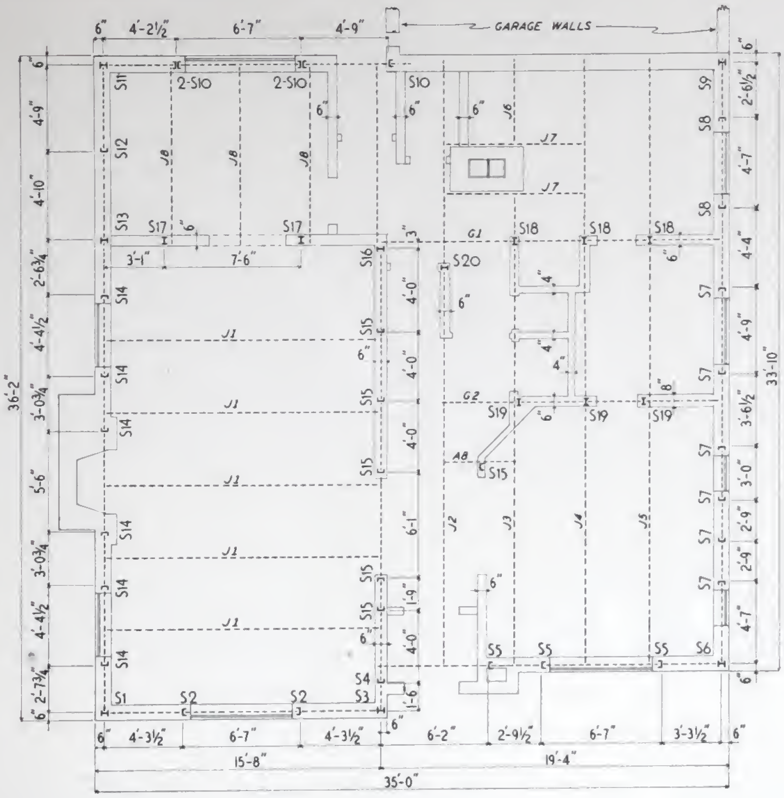


Fig. 3

THIRD STEP—Locating the First Story Steel Studs in their Relation to Door and Window Openings and Partitions. Dotted Lines Indicate Position of First Floor Joists and Sills Located in First Step.

FOURTH STEP—The Size of the Typical Stud is Computed as Explained in the Text

Studs Marked S1 to S20 are 3″ Channels, 4.1 Lb., or 3″ I-Beams, 5.7 Lb., as Shown

On the second floor (Fig. 6) the joists marked J21 sustain the concentrated load of the set-back wall in addition to their floor load. They are only 10½ feet long, however, and the typical 6 inch beam section is found to be adequate for this condition.

Reverting to the first floor, two girder beams, G1 and G2, carry the concentrated loads of floor beams J2 to J5 in addition to the loads of the upper floors transmitted through Studs S18, S19, S20 and the Stud S15 carried by A8. The proper size of these beams cannot be taken directly from the tables of uniformly distributed loads in this booklet, but must be computed by the theory of flexure as explained in the engineering handbooks. It is then found that the critical case is the left hand span of beam G1 (between the interior wall and column C1) which requires a section modulus of 13.45 in.^{3}. It is seen from the table on page 34 that an 8 inch I-beam, B39, weighing 17 lb. per foot, has a section modulus of 14.3 in.^{3}, and this section is used for both beams.

Locating Studs. The floor layout is now tentatively completed, tentatively in the sense that it is desirable to consider also the location of the steel studs in their relation to the joists before finally dimensioning the floor framing. The stud spacing will, to a large extent, be governed by the location of the door and window openings. Should it be necessary, a joist can be shifted a few inches to either side to permit a stud to rest directly on the sill rather than on top of the joist.

The next step, therefore, is to locate the studs. Fig. 3 shows the architectural plan of the first floor with the doors and windows outlined. The dotted lines indicate the position of the center-line of the joists and sills, just located. Considering one wall at a time, and beginning at the left front corner, an I-beam stud (S1) is located 6 inches back of each corner in order that its flanges may clear the brick of the meeting walls. Channel studs (S2) are then spaced on both sides of the

window openings, as shown, with their flanges turned in to support the rough window frame. Each wall is framed in turn, using I-beams at corners and channels at intermediate points. The selected form of section for the studs must be such as will suit the contemplated method of placing and connecting the framework. In this house it was decided that, during the process of erection, the studs were to be aligned vertically and tied together at the top by the second floor girt or header, the studs being attached top and bottom to the horizontal girts by means of arc welds. A view of the right front corner is shown in Fig. 5 illustrating the first story studs welded in place. The details of the welded connections are shown on page 22.

Before computing the strength of the stud section, the framing of the upper floors should be laid out so that the total load for any single stud may be determined. Fig. 6 shows the second floor architectural plan with the floor beams and the second story studs located. In general, the framing is similar to that of the first floor, except that the rear wall of the house is set back to form a small terrace or porch on a part of the roof over the library and kitchen.

As was mentioned on page 8, it is desirable, as far as practicable, that each second-story stud be placed directly over a first-story stud. The steel girt is generally strong enough to transmit the load of both the upper studs and the adjacent floor beams to the lower studs. In some cases, particularly over wide openings, where the girt is required to carry one or more studs and floor joists between supports, a heavier section may be required to develop additional resistance to bending. In this house the strength needed at such locations was secured by welding a second 3 inch I-beam to the bottom flange of the regular girt, as shown in Figs. 8 and 9.

The third floor is framed as shown in Fig. 7. The steeply pitched roof cuts through the second-story ceiling and necessitates setting the third-floor

Fig. 4

Steel Floor Framing for Dining Room
The Welded Connections to the Steel Sill A4 are Clearly Seen

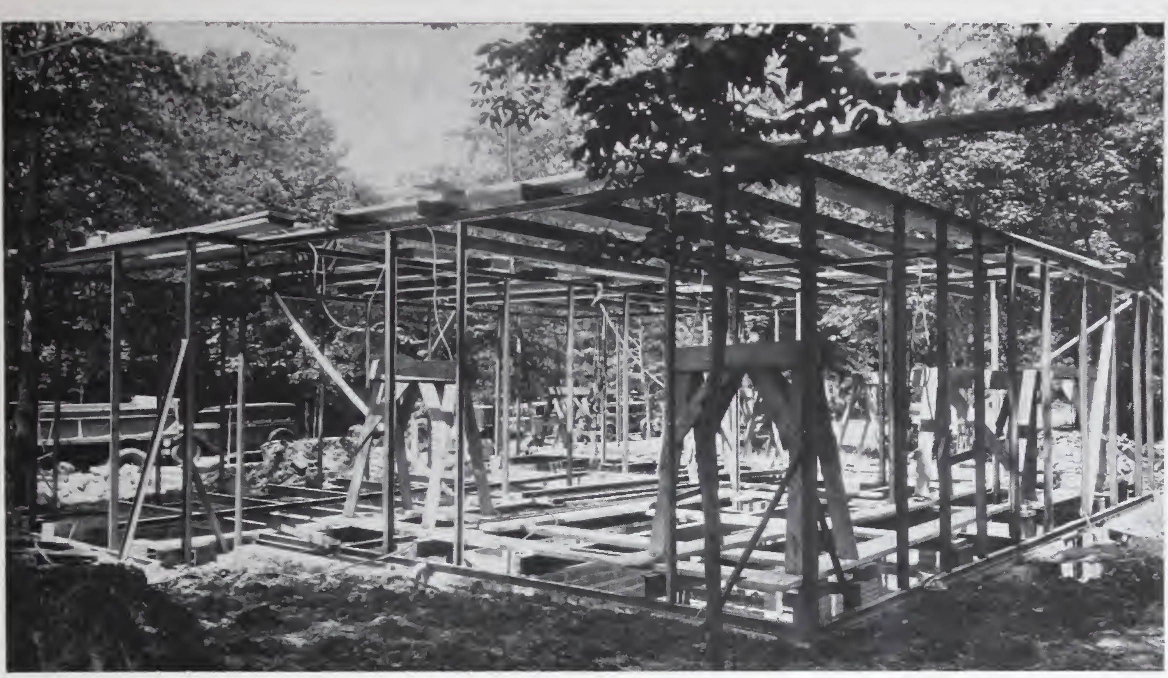


Fig. 5

First Story Steel Studs Welded in Place

The Second Floor Joists Rest Directly Upon, and are Welded to the Steel Girt at the Second Floor Line.

framing 1′–7⅝″ back from the center line of the girts. Fig. 9 shows how the set-back at different levels was framed by welding the sloping channels to the ends or the webs of the floor joists.

Computing Size of Stud. With the floors laid out and the studs located, the size of the studs may now be determined. As far as possible the procedure will follow the general principle of making all the intermediate studs alike and equal in strength to the one carrying the greatest typical load. The critical stud occurs in the front elevation of the first story next to the right corner. A layout of the framing in question is shown in Fig. 8.

As explained under Basis of Design, pages 6 and 7, when the house is at a stage of construction in which the studs are not anchored to the enveloping wall materials, each stud must be sufficiently strong to support the weight of the structural frame above it, plus whatever loads may be added by the presence of workmen, staging and building materials. These erection conditions should be provided for by adding a load of at least one thousand pounds (1 kip).

The determination of the floor and roof areas contributing loads to a stud is largely a matter of the designer's judgment, based upon an inspection of the floor plans. For the residence under construction, in which the partitions on the second and third floors are located near to, or are approximately symmetrical about, the central axis and the stud spacing is fairly uniform, it is reasonable to assume that the average tributary area for the third floor and roof is the same as for the second floor. The second floor area supported by the stud is 5 feet wide and 7½ feet long (half the joist span), or 37½ square feet. The total floor area to be considered, therefore, is 3 x 37½ = 112.5 square feet. Since the average weight of the floor framing is 3 lb. per sq. ft., the load on the unbraced stud from these areas is 112.5 x 3 lb. = 338 lb. = 0.34 kips. To this should be added the weight of the wall framing (5 x 8 x 2 = 80 lb. = 0.08 kip) and the assumed erection load of 1 kip. The temporary load is then 1.42 kips.

The load on the stud in the completed structure may be calculated as follows. The roof load is 29 + 8 = 37 lb. per sq. ft. of roof surface, equivalent to 57 lb. per sq. ft. of horizontal projection. Most of the third floor area tributary to the stud load is outside the occupied portion, and the floor load will be taken equal to the dead load only, namely 25 lb. per sq. ft. The second floor load is the sum

of the full dead and live loads, total 65 lb. per sq. ft.

Weight of Floors and Roof = 37.5 (57 + 25 + 65)	=	5.50 kips
Weight of 2nd Story Wall Area = (8 x 5) x 70	=	2.80
Total Vertical Load on Stud	=	8.30 kips
Bending Factor = 1.3 kips x Spacing = 1.3 x 5	=	6.50
Total Design Load	=	14.80 kips

Referring to the table of Safe Loads for Sections used as Columns or Studs on page 49, it is seen in the lower table, under the heading for members 9 ft. long, that a 3 inch channel, C10, weighing 4.1 lb. per foot, as a stud will carry a load 14.5 kips when braced on its minor axis at intervals of 37 inches, and it is seen in the upper table that it will support a load of 3.8 kips when unbraced on either axis. Since the braced value is within 2 percent of the computed load the 3 inch channel will be adequate for this residence. As actually built the stiffness of the stud was increased by spacing the anchors only 18 to 21 inches apart.*

It should be noted that a 3 inch I-beam was substituted for the intermediate channel stud at all corners and in the bearing partitions, such as those between the library and living room and between the breakfast room and the kitchen and the dining room. The greater strength that accompanies the larger area and symmetrical shape of an I-beam makes it more suitable for conditions where considerable stress is apt to occur.

These steps conclude the design of the typical floor and wall framing. Fig. 10 illustrates the manner in which the work of other trades was

*Instead of using this average method, and adding an arbitrary bending factor, individual reactions may be computed and the bending calculated. Thus figured the total permanent stud load is 14.83 kips, or less than one percent greater than by the method used. This negligible difference need not affect the size of stud to be adopted.

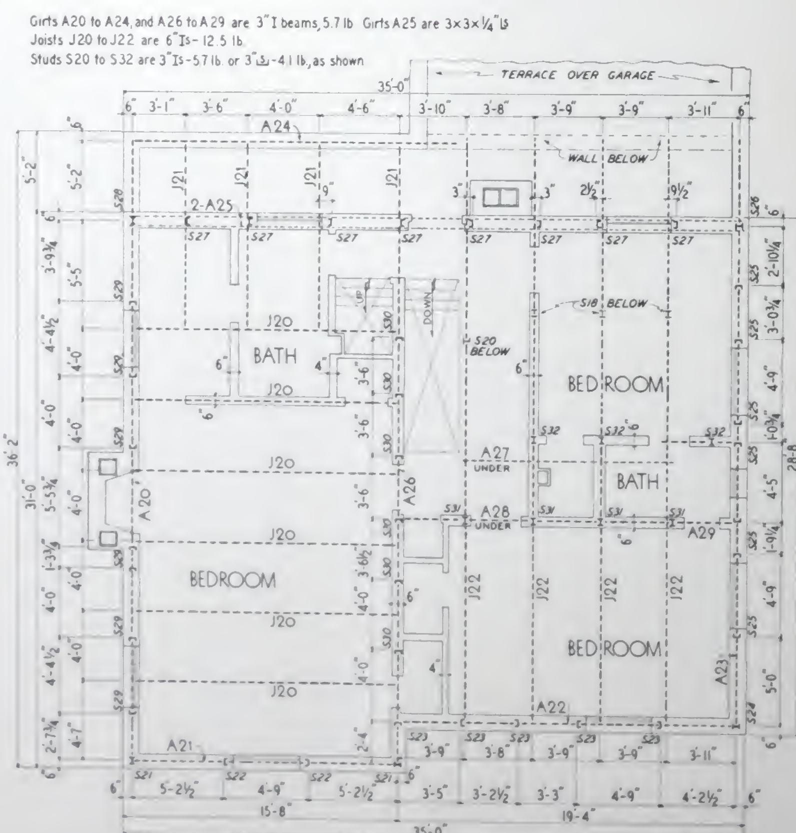


Fig. 6

Second Floor Architectural and Steel Framing Plan—Showing Also Location of Second Story Studs

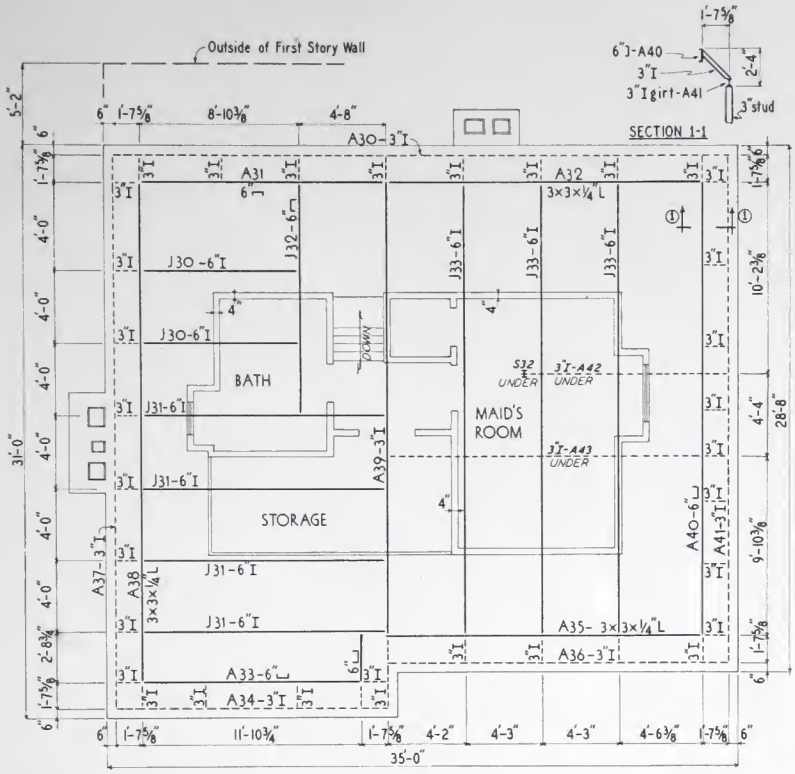


Fig. 7

Third Floor Architectural and Steel Framing Plan—Sizes of Members are Shown on Plan

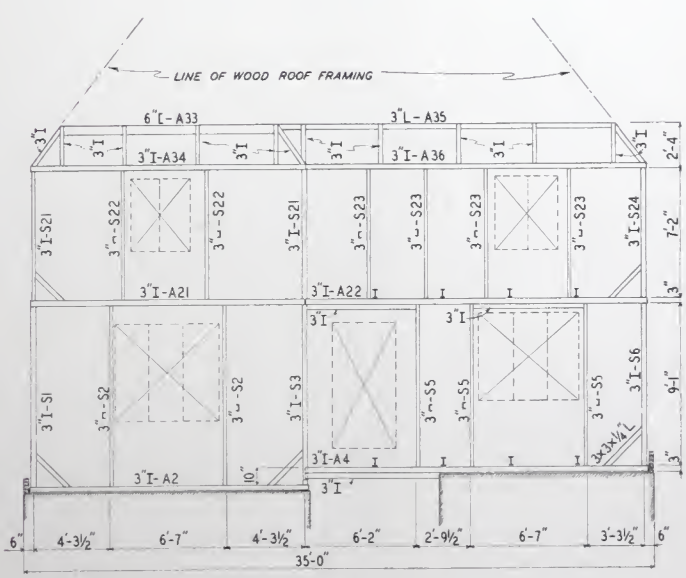


Fig. 8

Framing of Front Elevation. Additional 3″ I-Section is Used Under Girts Over Wide Door and Window Openings Supporting Concentrated Loads of Floor Joists.

combined with the steel frame. It now remains to compute the size of the basement columns C1, C2 and C3 (Fig. 2) previously referred to on page 10. Of these three columns, C3 carries the greatest load, which may be calculated as follows.

For the reasons given above in the design of a typical stud, the tributary area for the column on each floor may be assumed equal to that on the first floor. The total load for the first and second floors is 65 lb. per sq. ft. An adjustment for the unoccupied portion of the third floor may be made by reducing the live load to an average of 20 lb., making the total load 45 lb. per sq. ft. The roof load on the projected area is again 57 lb. An assumption that one-half of the weight of all partitions within the contributing area is carried by the column is approximately correct.

Tributary Area (1st Floor)

$= \frac{1}{2}(14'-8'' + 8'-7'') \times \frac{1}{2}(7'-5'' + 7'-8'')$

$= 11'-7\frac{1}{2}'' \times 7'-6\frac{1}{2}'' = 88$ sq. ft.

Load of 3 Floors and Roof

$= 88\,(57 + 45 + 65 + 65) = 20.4$ kips

Partition Loads

1st Story	$= \frac{1}{2}(31 \times 8 \times 30) =$	3.7 kips
2nd Story	$= \frac{1}{2}(25 \times 8 \times 30) =$	3.0
3rd Story	$= \frac{1}{2}(36 \times 7 \times 8) =$	1.0
Total Column Load		= 28.1 kips

For an unbraced column 8 feet long, and using the values to the left of the solid zig-zag line, the upper table on page 49 indicates that Section H1, a 4 inch H-column weighing 13.8 lb. per ft., would be amply strong to carry the load. If a pipe column were preferred, the table on page 48 indicates that a 3 inch pipe, having an outside diameter of $3\frac{1}{2}$ inches, 0.216 inch thick, and weighing 7.57 lb. per ft., would be suitable. Actually, the stronger Section H-3, a 6 inch H-column, weighing 20 lb. per ft., was used.

Fig. 9

The Steeply Pitched Roof Cutting Through the Second Story Ceiling Requires the Steel Framing to be Set Back. Connections are Made Easily by Arc-Welding.

Fig. 10

View of Portion of First Story. Wiring is Carried in Steel Pipe Conduits Laid Before Masonry Work is Begun. This View Shows Wood Window Frames Fastened to Wood Grounds and Wedged Between Steel Studs Prior to Bricking Up. The Inside Furred Clay Walls are Staggered to Increase Insulating Value, Providing an Individual Sealed Air Space at Each Tile.

The results of the detailed computations that have been presented in pages 10 to 19 of this booklet are, of course, applicable only to the particular residence considered. The general method employed, however, with proper modification to meet the desired arrangement, lengths and spacing of the members, will be found suitable for determining the sizes of steel required to frame the majority of small residences which an architect is called upon to design. It will also apply to many of the problems that occur in large residences.

Illustrations of Steel Framed Residences

The information contained in pages 21 to 32 was compiled from data furnished through the courtesy of the designers and builders of the residences illustrated. This publication does not undertake to distinguish between features that are patented and those that are not; and of course does not convey the right to use any features that are patented.

Almost any system of steel frame construction can be selected for use in houses of an infinite variety of architectural styles and arrangement, employing any of the wall and floor surfacings that are commercially available. Steel frame houses have been built along the lines of Early Colonial, French Norman, English Georgian, and other conventional styles of architecture, as well as in the more recent International style where the employment of flat roofs and broad expanses of windows is facilitated by the use of steel.

The following is a partial list of materials used in a large number of steel framed residences that have been investigated. It is to be noted that certain of these materials, or combinations of materials, are mutually exclusive.

Floor Construction:

FRAMING. Rolled steel beams and channels, sheet steel sections, metal lumber joists, open web steel joists.

SUB-FLOOR BASE. Paper back steel mesh, expanded metal lath, battledeck plate, corrugated steel or asbestos board sheets.

SUB-FLOOR. Concrete, light weight concretes, wood sheathing, hollow tile, reinforced gypsum slabs.

FINISHED FLOOR. Hardwood, rubber tile or linoleum over mastic, composition, terrazzo, tile, cork.

Wall Construction:

FRAMING. Rolled steel I-beams, angles or channels. Metal lumber.

EXTERIOR. Brick, cut stone, precast concrete stone, stucco over wire mesh or hollow tile, metal shingles and siding, wood shingles and siding.

INTERIOR. Conventional finishes over hollow tile, metal lath, ribbed wire mesh, paper back steel mesh, light steel sheets.

INSULATION. Air, cork, celotex, rock wool, gypsum board, masonite, transite, insulite, ferroclad, and many other compositions.

Roof Construction:

FRAMING. Although flat roofs may be economically framed with steel, it has generally been found that the use of steel framing for sloping roofs has proved relatively more expensive than for floor and wall construction.

COVERING. A wide variety of standard roofings may be used over either steel or wood framing.

The succeeding pages describe five systems of steel frame construction which illustrate some of the many ways in which steel may be utilized. As pointed out in the Foreword, other systems are being used with results that are entirely satisfactory. Many of the features of one system are capable of being adapted to and used interchangeably with features of another.

The following residences were selected because each is typical of systems of construction whose main wall framing members differ either in the kind of steel members used or in the manner in which they are assembled. Any type of floor framing may be combined with either type of wall framing. From the standpoint of steel wall framing the class characteristics are indicated in the following table.

STEEL WALL FRAMING CLASSIFICATION

CHARACTERISTICS					ILLUSTRATIVE EXAMPLE						
	WALL FRAMING						WALL FRAMING				TOTAL FRAMING
Class No.	MATERIAL: Steel Members	MATERIAL: Envelope	Steel Fabricated At	Delivery Unit	Page	Name of Residence	Steel Members	Weight (a) of Steel per Sq. Ft. of Wall (Lbs.)	Envelope	Steel Floor Framing	Average Weight of Steel per Room (Tons)
1	Rolled Shapes	Non-Ferrous	Site	Single Studs and Girts	22 23	Schwarz	Channels and I-Beams	2.3	Brick and Tile	I-Beams	1.25
2	Rolled Shapes	Non-Ferrous	Shop	2—Man Members	24 25	Field	Angles	2.7	Stucco	Open Web Joists	2.17 (b)
3	Rolled Shapes	Non-Ferrous	Shop	4—Man Members	26 27	Moulton	Channels and Angles	3.0	Brick and Tile	Channels	1.18 (c)
4	Rolled Shapes	Ferrous	Shop	Single Studs and Girts	28 29	Clawson	Angles	3.9 (d)	Ferro-Clad under Ferro-Enamel Shingles	Open Web Joists	2.25 (d)
5	Hot Rolled Strip	Non-Ferrous	Shop	Single Studs and Girts	30 31 32	Scott	Metal Lumber	1.8	Brick and Stucco	Metal Lumber	1.15

(a) Average weight of studs, girts, and framing around openings.

(b) Living room, 20 x 35 ft., considered equivalent of two ordinary rooms.

(c) Number of rooms considered as 7, since room above garage is not framed with steel.

(d) Not including weight of enveloping material.

RESIDENCE OF R.H. SCHWARZ — CLEVELAND, OHIO.

ARCHITECT – GEORGE H. BURROWS — BUILDER – McKAY ENGINEERING COMPANY

This house is of French-Norman type, with 8 rooms, 3 baths, and attached garage. Ten tons of steel were required for framing, each piece being light enough to be handled by two men. The foundations are hollow tile on concrete footings. Roof framing is wood. Steel sash is used with wood frame and trim.

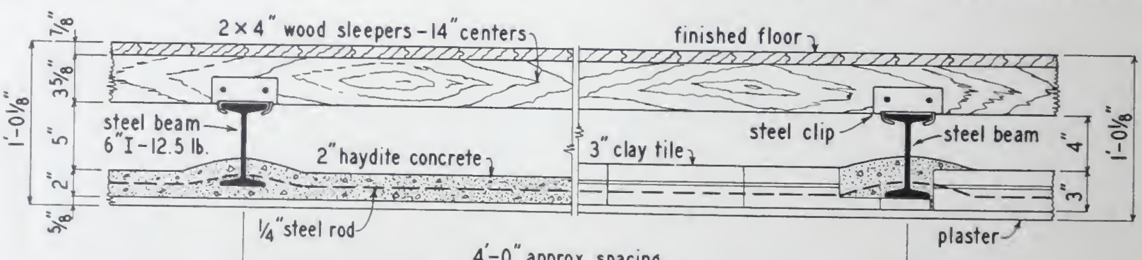
Plain steel material, cut to length, was furnished from warehouse stock and fabricated at the site by arc welding as a part of the erection process.

VIEW OF COMPLETED RESIDENCE

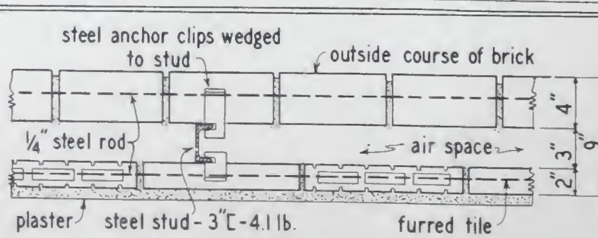
For arrangement and computation of the steel members, see pages on TYPICAL STEPS IN DESIGNING STEEL FRAMING.

TYPICAL SECTION THROUGH FLOORS

CONCRETE CEILING ON FIRST FLOOR ONLY — CLAY TILE CEILING ON OTHER FLOORS



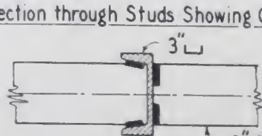
The air space at each floor is fire-stopped by cement mortar between the enveloping masonry and the edges of the 3" I beam girt.



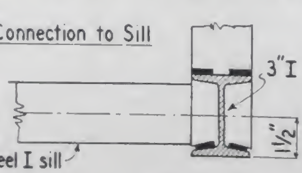
PLAN VIEW OF EXTERIOR WALL CONSTRUCTION

TYPICAL ARC WELDING DETAILS (Fillet welds shown solid black.)

Section through Studs Showing Connection to Sill

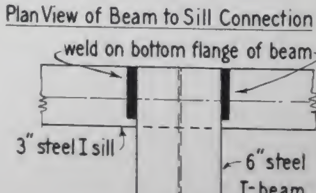


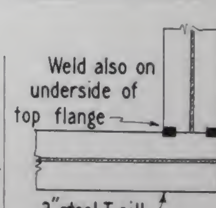
Intermediate Steel Stud



Steel Stud at Corner

Plan View of Beam to Sill Connection





Section through Sills at Corner

RESIDENCE OF R.H.SCHWARZ CLEVELAND, OHIO

ARC WELDING SECOND FLOOR GIRT TO STUDS BELOW

Corner studs are 3" steel I-beams, 5.7 lb. per ft. Intermediate studs are 3" steel channels, 4.1 lb. per ft. Bottom sill and second floor girt are 3" steel beams. Note the knee brace angles in the foreground connecting corner stud to sills.

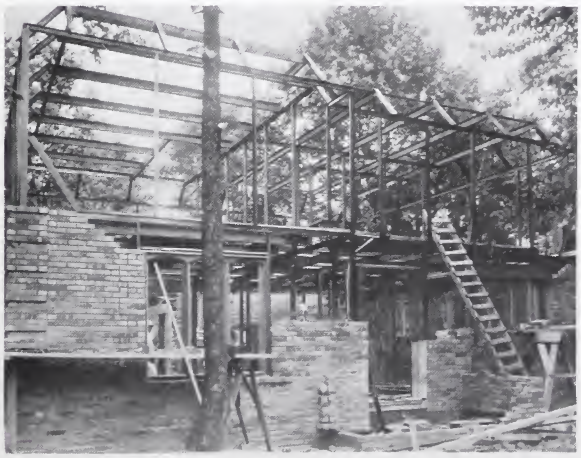
EXTERIOR WALL CONSTRUCTION

Walls are 2" hollow tile, 3" steel studs, and 4" brick. Both tile and brick are reinforced with 1/4" steel pencil rods. Studs are braced vertically by anchors to brick and tile at approximately 18" intervals.

FORMS READY FOR POURING CONCRETE CEILING

Lower flanges of 6" steel I-beam carry 2" of concrete.

Upper flanges support wood flooring. See detail opposite page.



STEEL FRAME PARTIALLY ENCLOSED

Masonry work began as soon as framing was completed.

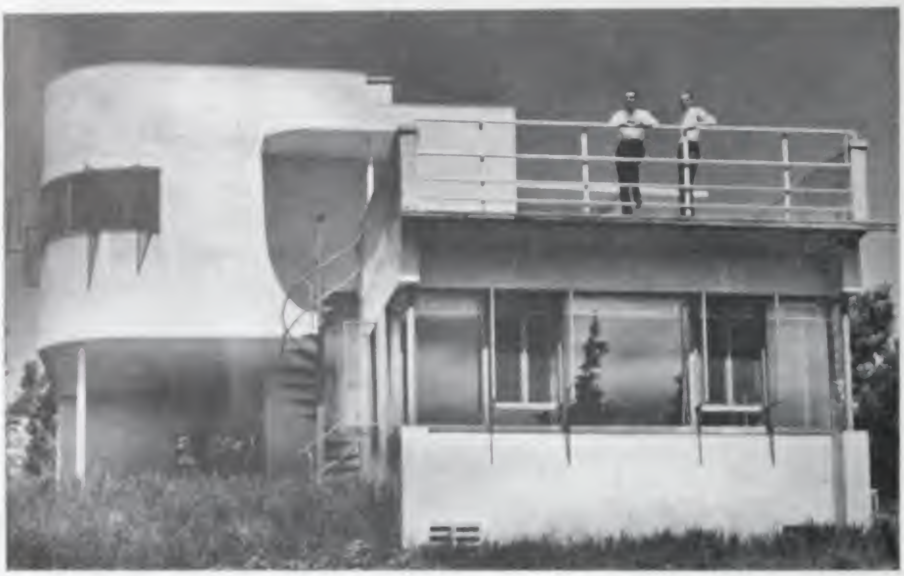
Difficult connections at eaves simplified by use of arc welding.

RESIDENCE OF FREDERICK V. FIELD — NEW HARTFORD, CONN.

ARCHITECTS – HOWE & LESCAZE, NEW YORK

STRUCTURAL ENGINEER – C. O. SKINNER

Located on a wooded hilltop, this house of Modern design contains 5 rooms, 2 baths, and roof terrace. 13 tons of steel required for framing. Foundations and retaining walls are monolithic stone concrete. Exterior door frames are steel without trim. All doors are flush Kalamein, covered with furniture steel; the exterior doors being finished in blue duco, interior doors in beige duco.



FRONT ELEVATION OF RESIDENCE (SOUTH)

Steel frame is arc welded and veneered with stucco.

End of living room entirely enclosed in glass.

Interior stairs are structural steel. Casement windows with metal sash are set in angle frame welded to steel studs.

The roof over living room is utilized as a terrace, covered with 6×6" quarry tiles set on top of built up roofing.

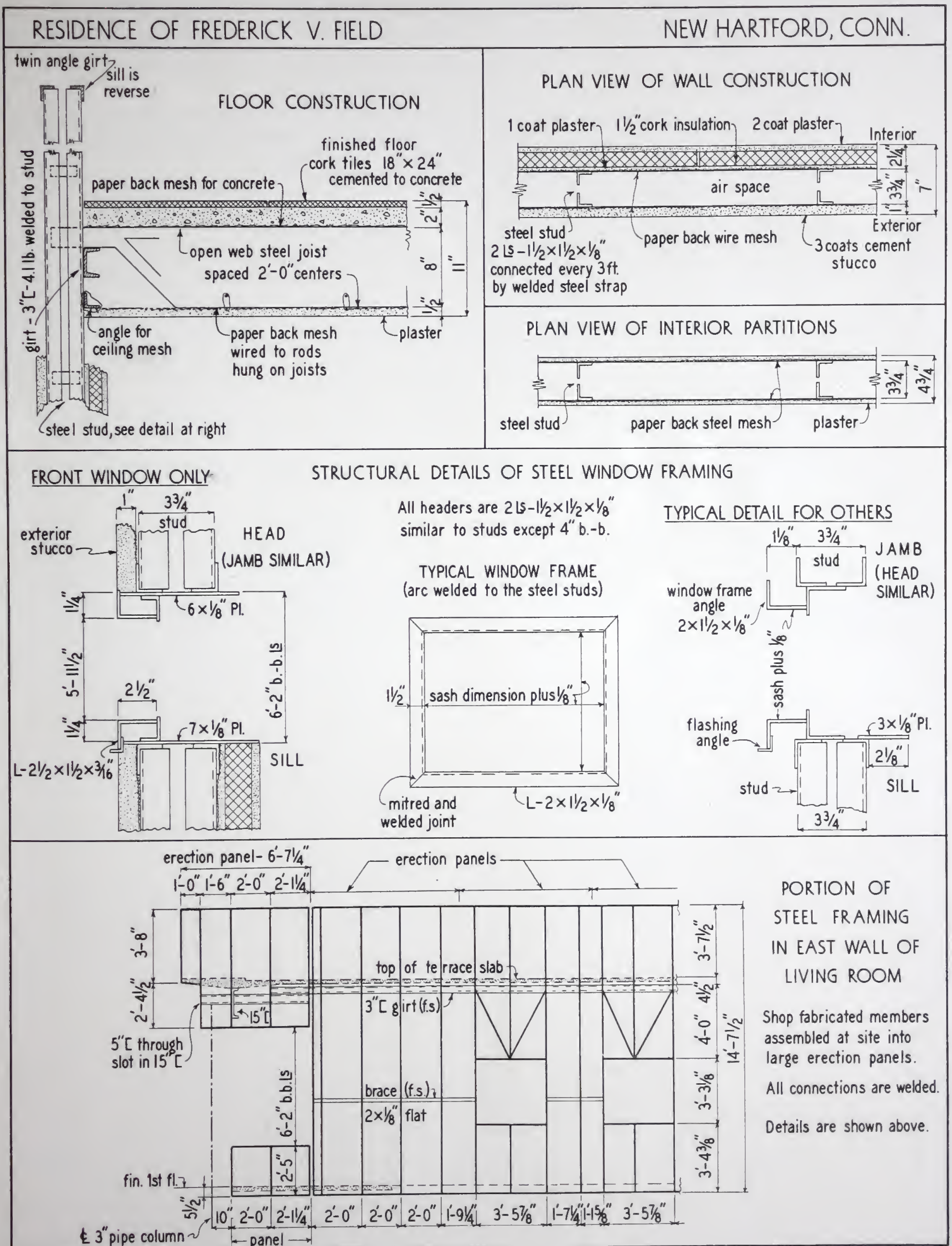
(PHOTOS BY RALPH STEINER)

Note maximum light and ventilation securable with steel framing. Floors are laid with cork in 18 × 24" tiles. Roofs and exterior walls are insulated with 1½" cork slabs.

BELOW: INTERIOR VIEW OF LIVING ROOM

ABOVE: EAST ELEVATION OF RESIDENCE

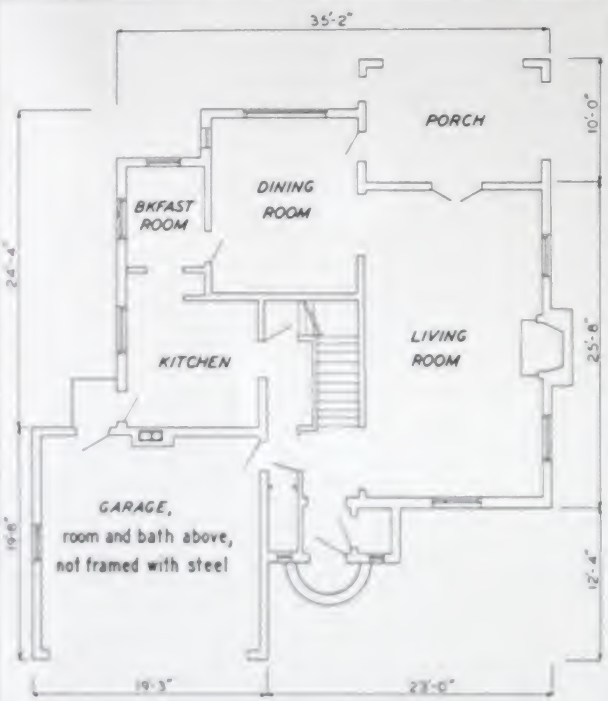
Exterior side of steel frame is covered with American Steel & Wire Co. paper back wire mesh for stucco, over which 3 coats of cement stucco are laid. Projecting concrete roof slabs are steel framed. All exposed concrete is finished with cement.


RESIDENCE OF FREDERICK V. FIELD
NEW HARTFORD, CONN.
FLOOR CONSTRUCTION
twin angle girt
sill is reverse
girt - 3"[-4.1 lb. welded to stud
finished floor cork tiles 18"×24" cemented to concrete
paper back mesh for concrete
open web steel joist spaced 2'-0" centers
angle for ceiling mesh
paper back mesh wired to rods hung on joists
plaster
steel stud, see detail at right
PLAN VIEW OF WALL CONSTRUCTION
1 coat plaster
1½" cork insulation
2 coat plaster
Interior
air space
Exterior
steel stud 2 Ls-1½×1½×⅛" connected every 3 ft. by welded steel strap
paper back wire mesh
3 coats cement stucco
PLAN VIEW OF INTERIOR PARTITIONS
steel stud
paper back steel mesh
plaster
STRUCTURAL DETAILS OF STEEL WINDOW FRAMING
FRONT WINDOW ONLY
exterior stucco
stud
HEAD (JAMB SIMILAR)
6×⅛" Pl.
7×⅛" Pl.
L-2½×1½×3/16
SILL
6'-2" b.-b. Ls
All headers are 2 Ls-1½×1½×⅛" similar to studs except 4" b.-b.
TYPICAL WINDOW FRAME (arc welded to the steel studs)
sash dimension plus ⅛"
mitred and welded joint
L-2×1½×⅛"
TYPICAL DETAIL FOR OTHERS
JAMB (HEAD SIMILAR)
window frame angle 2×1½×⅛"
sash plus ⅛
flashing angle
3×⅛" Pl.
stud
SILL
erection panel- 6'-7¼"
erection panels
top of terrace slab
3"[girt (f.s.)
15"[
5"[through slot in 15"[
brace (f.s.)
2×⅛" flat
6'-2" b.b. Ls
fin. 1st fl.
℄ 3" pipe column
panel
PORTION OF STEEL FRAMING IN EAST WALL OF LIVING ROOM
Shop fabricated members assembled at site into large erection panels.
All connections are welded.
Details are shown above.

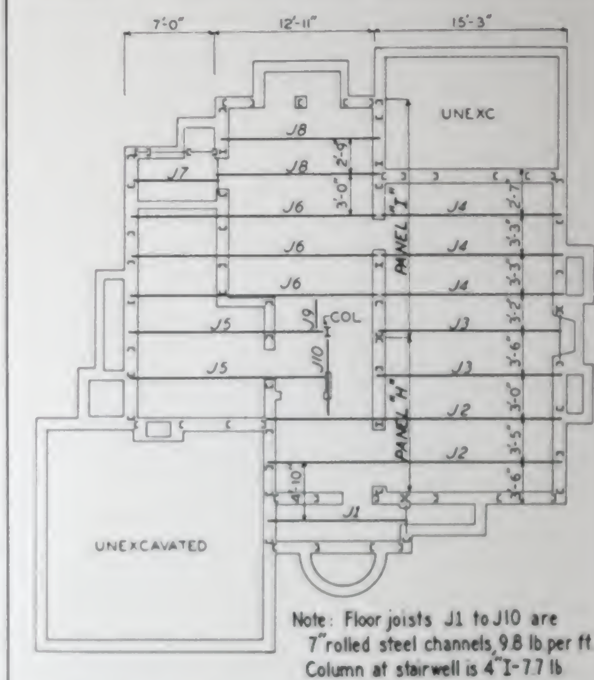
RESIDENCE OF A. K. MOULTON — CLEVELAND, OHIO.

ARCHITECT – MYRON T HILL — BUILDER – STEEL-BILT HOMES, INC.

This house, of English Architecture, has 8 rooms, 3 baths, and large recreation room in basement. Garage is attached. Floors and walls framed with 8 ¼ tons of steel, roof framed with wood. Wall studs are arc-welded in shop into large panels, trucked to site, and erected by welding adjacent panels together. This erection method permits simple shop fabrication, eliminating punching and special cutting. Heating is by conditioned air.

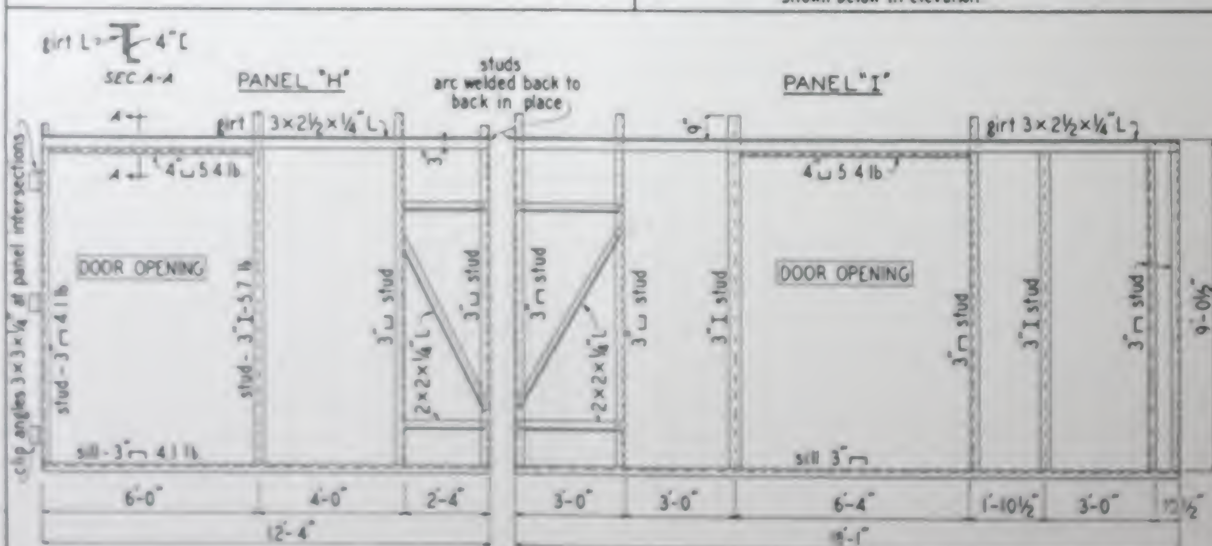


FIRST FLOOR ARCHITECTURAL PLAN



FIRST FLOOR STEEL FRAMING PLAN

Two of the interior wall panels, H and I, indicated on this plan, are shown below in elevation.



FIRST STORY INTERIOR WALL PANELS "H" AND "I" (Exterior wall panels similar.)

Their location is indicated on the framing plan above. Note that the steel stud spacing is flexible, and may be varied to suit openings. A 4" steel channel is used to reinforce the angle girt above wide door openings, and 3" I-beam studs used to carry the resulting heavier loading.

RESIDENCE OF A. K. MOULTON — CLEVELAND, OHIO

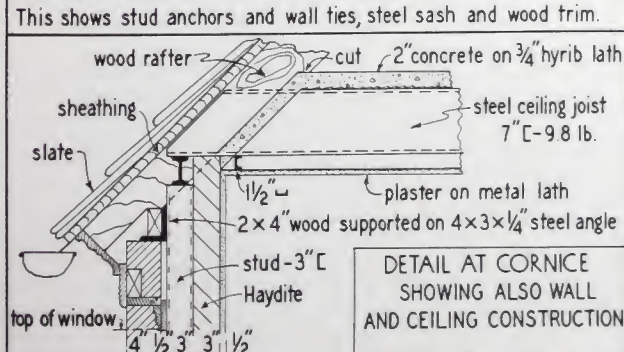
VIEW DURING CONSTRUCTION
(Garage not yet started)

Note method of joining steel framing panels at corners by clip angles. Third floor concrete is carried down in plane of roof rafters. The steel channel sills rest directly upon foundation of light weight concrete blocks. Metal ducts seen in foreground and also through entrance vestibule are for the conditioned air heating system.

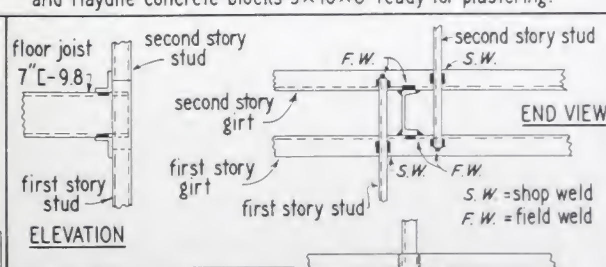
The wall framing permits wires, heating and water pipes to be carried past floors without interference by girts.

INTERIOR VIEW OF CORNER PRIOR TO BACK PLASTERING
This shows stud anchors and wall ties, steel sash and wood trim.

INTERIOR VIEW— showing furring on ceiling, rock wool insulation, and Haydite concrete blocks 3×16×8" ready for plastering.



DETAIL AT CORNICE SHOWING ALSO WALL AND CEILING CONSTRUCTION



METHOD OF CONNECTING STEEL JOISTS TO STEEL WALL PANELS

RESIDENCE OF DUDLEY CLAWSON
ARCHITECT–CHAS. BACON ROWLEY

CLEVELAND, OHIO
BUILDER–GEO. L. DUBIN, INC.

This residence, in the English Georgian cottage style, contains 8 rooms and bath. It is covered with porcelain enameled steel shingles laid over ferro-clad panels. Structural steel angles are used for wall framing, metal lumber for partitions, and open-web steel joists for floors. Steel sash used throughout.

VIEW OF COMPLETED RESIDENCE

Exterior color is buff, with green horizontal belt courses.

The roofing and siding shingles, and the chimney tiles are of ferro-enamel construction. The shingles are backed with asphalt roofing felt and made up ready to lay in units 36 inches long.

EXTERIOR WALL FRAMED WITH STEEL ANGLES

Structural steel frame is shop riveted and field bolted. Note use of tie rods to brace window framing. Sill angles are bolted to the brick foundation.

INTERIOR PARTITIONS FRAMED WITH METAL LUMBER

4" I-beam studs (2 steel channels welded back to back) are spaced approximately 21 inches apart. 8" steel open-web joists are arc welded directly to top of partition panel.

RESIDENCE OF DUDLEY CLAWSON — CLEVELAND, OHIO.

Weight of Steel Used in this Residence:

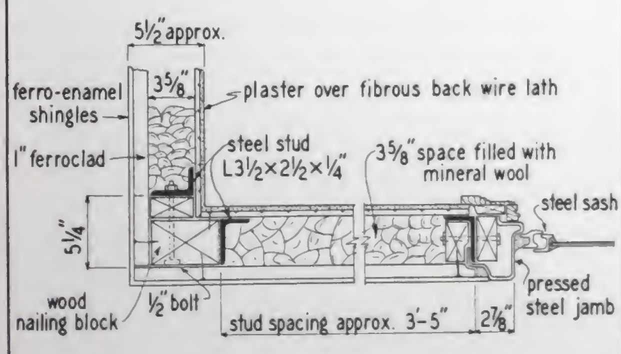
	Tons	
Wall Framing	11.00	
Open Web Joists	5.25	
Metal Lumber Partitions	1.75	
Total Framing		18.00
Ferro-enamel Shingles	1.67	
Ferro-clad Panels	5.75	
Casement Sash	1.33	
Window Frames	1.00	
Total Envelope and Finish		9.75

WALL FRAMING ERECTED

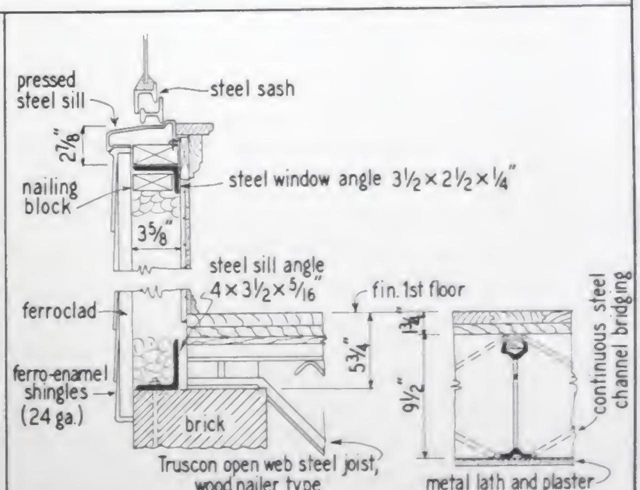
Attaching ferro-clad panels to exterior wall framing. For nailing, a 2 x 4" block was bolted to each stud, header, and sill.

Ferro-enamel shingles were then nailed over these insulating panels.

Ferro-enamel tiles being applied to interior walls. These tiles are cemented to grooved fibre board panels attached to the steel studs



TYPICAL PLAN VIEW THROUGH EXTERIOR WALL

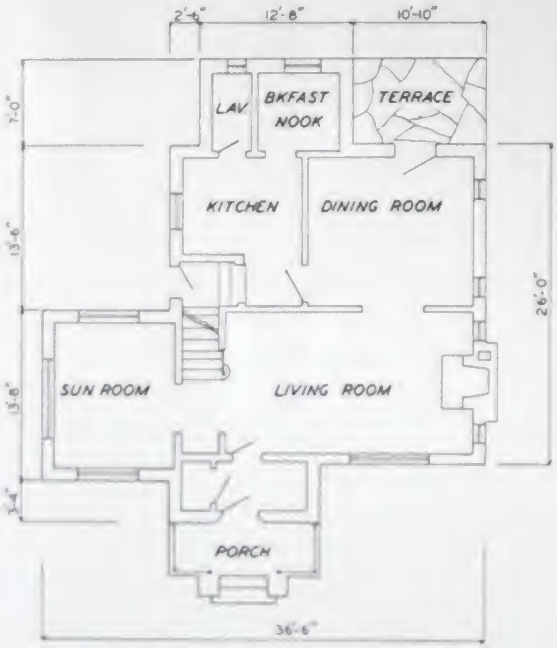


TYPICAL SECTION THROUGH WALL AND FIRST FLOOR

RESIDENCE OF THOMAS C SCOTT — DETROIT, MICHIGAN

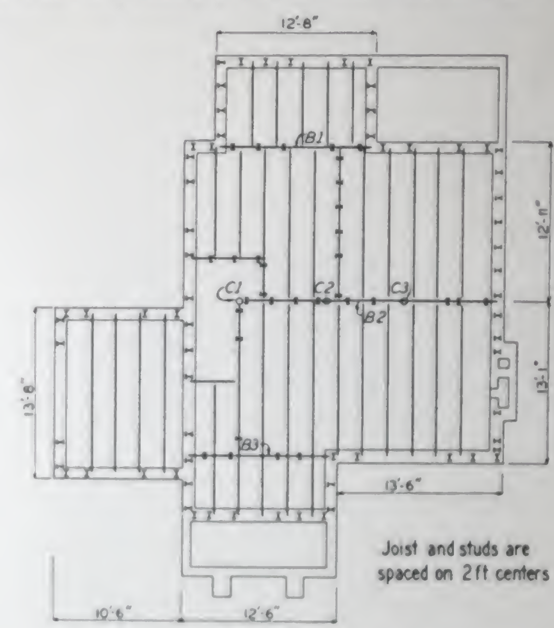
ARCHITECT – GEORGE R. WELLER — BUILDERS – STRAN-STEEL CORPORATION

This 7 room residence of modern English type is covered with brick, stucco, and wood siding. The house is framed with 8 tons of steel joists, studs, and rafters, so formed as to permit other materials to be nailed directly to the steel. Carpenters were employed to erect the house. Fire-resistive construction, using concrete sub-floor with fire cut off at each floor, special fire resisting roof, and steel framing, made possible a permanent residence, and effected a reduction of 50% in insurance rates.

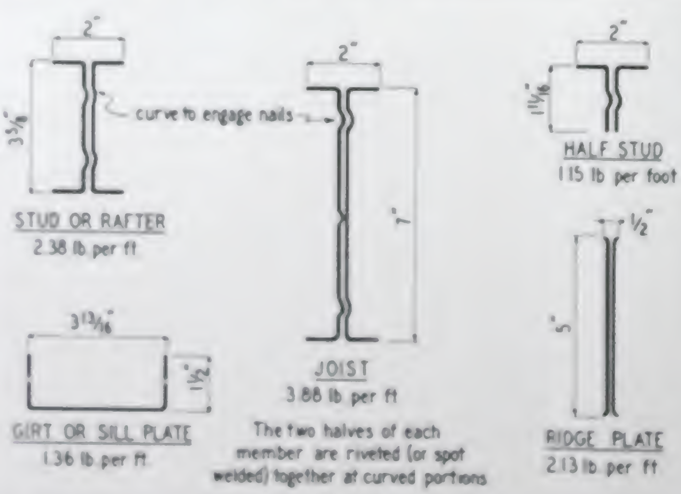


FIRST FLOOR ARCHITECTURAL PLAN

C1, C2, C3, are 4" steel pipe basement columns. B1, B2, B3, are 7" rolled steel I-beams. Other joists are of the metal lumber type shown below.



FIRST FLOOR STEEL FRAMING PLAN



STRAN-STEEL STRUCTURAL MEMBERS OF METAL LUMBER TYPE FORMED OUT OF LONG LENGTHS OF 16 GAGE (1/16" THICK) STRIP STEEL

Some sections reinforced by bending back metal to form two-ply flanges

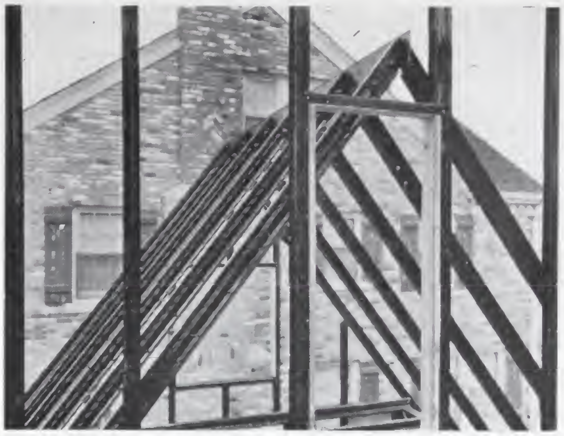
CUTAWAY VIEW SHOWING FLOOR CONSTRUCTION

The concrete slab is floated smooth to receive mastic for placing wood or any other suitable finish. The steel joists, resting on rolled steel beams, support wire lath or mesh, over which the concrete is poured.

RESIDENCE OF THOMAS C. SCOTT — DETROIT, MICHIGAN.

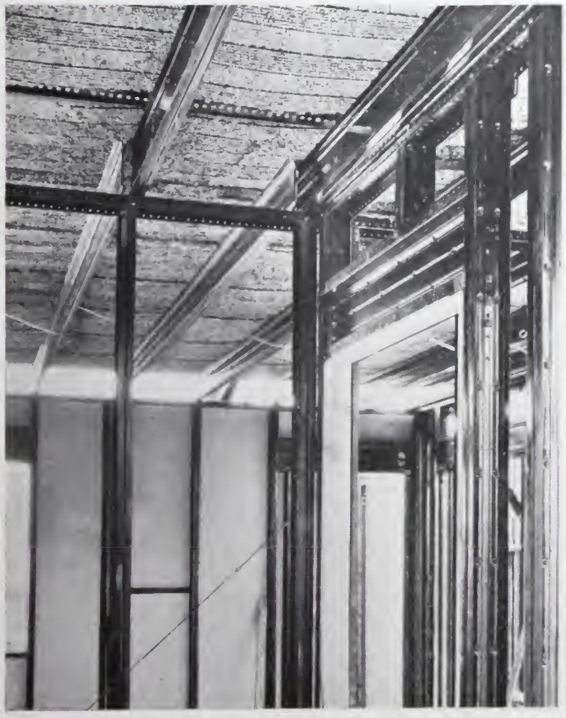
STEEL FRAMING AROUND STAIRWELL

Studs are doubled at corners. Another view of this stairwell is shown on the following page.



STEEL FRAMING OVER SUNROOM

The sloping steel rafters are bolted to the ridge plate by a connection plate bent at the site to the proper slope.



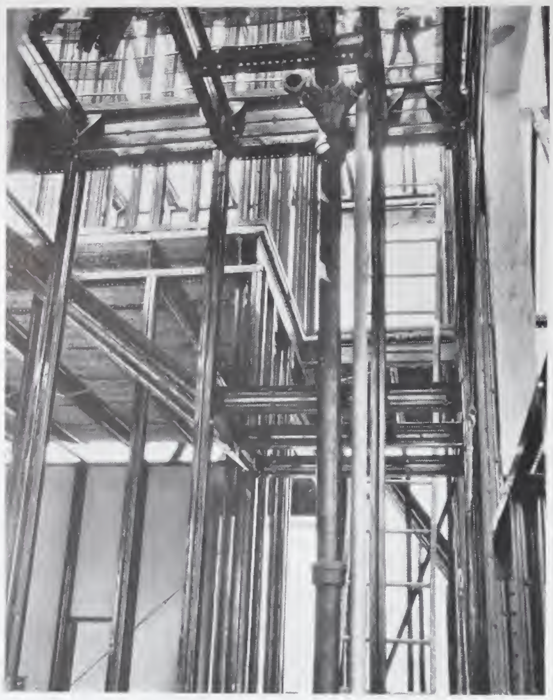
SECOND FLOOR STEEL FRAMING SEEN FROM BELOW

Steel bridging ties are nailed directly to joists. The exterior wall sheathing has just been applied. Door header is composed of a steel joist section and two steel sill plates.

SECOND STORY DOOR AND WINDOW FRAMING

Beyond the wall framing are seen the ceiling joists over breakfast nook and lavatory. The steel rods and turnbuckles are for truing the house during construction. They are removed after sheathing.

RESIDENCE OF THOMAS C. SCOTT DETROIT, MICHIGAN



VIEW OF STEEL STAIRWELL FRAMING FROM BELOW

Steel hangers used where steel joists frame into each other at right angles. The piping shown is concealed in the stair partitions.

LEFT ELEVATION OF STEEL FRAME

Steel sill plates are anchored to the foundation of sand-lime blocks topped with three courses of brick.

SHEATHING BEING APPLIED TO STEEL FRAME

Fibre insulating boards, 4 × 9 ft. × ½ inch thick, are nailed directly to studs. The nails clinch in the curved portion of the stud and thus are permanently held in place.

VIEW OF COMPLETED RESIDENCE

Steel sash is used throughout

Sections Suitable for Steel Framing

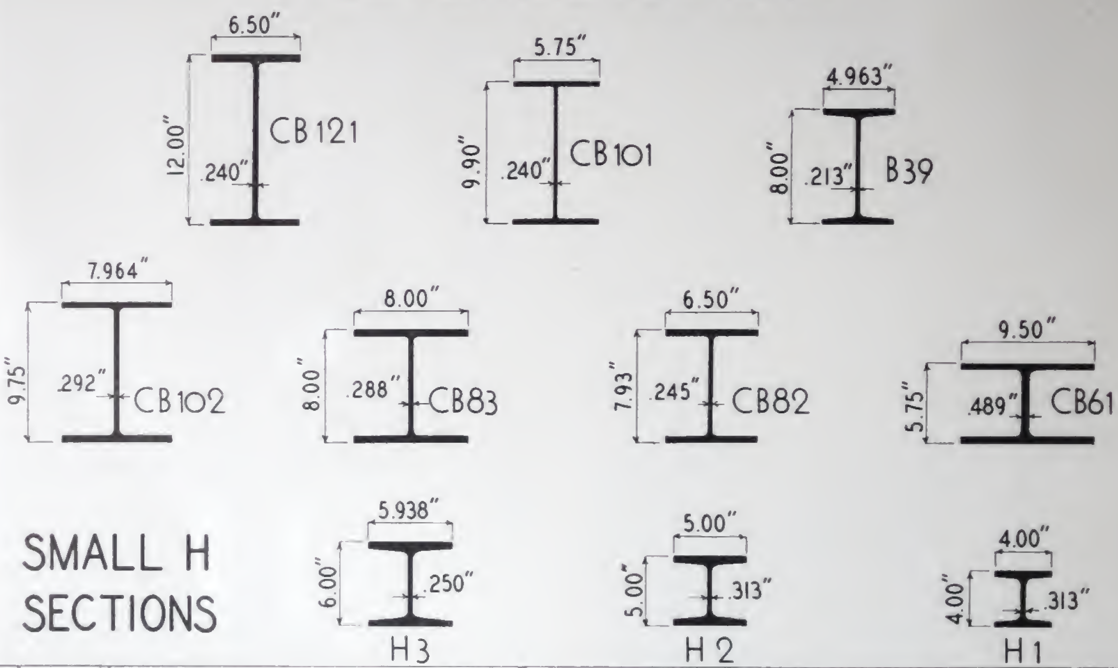
On the following pages are listed a selected range of steel sections suitable for small residence construction. Two new light weight I-beam sections are presented. B41 is 6 inches deep and weighs 10 lb. per foot. B42 is 7 inches deep and weighs 12 lb. per foot. If used within the loading conditions tabulated these sections in many cases will permit a saving in floor depth. For special conditions which may require steel material not listed herein reference should be made to the greater variety of products shown in the catalogs of the various Subsidiary Manufacturing Companies of United States Steel Corporation. See pages 52 to 54. Where like products are made by more than one subsidiary the sizes tabulated are those obtainable from either company.

Structural Shapes, Plates and Hot Rolled Strip. The structural shapes, plates and hot rolled strip listed, as well as usual sizes of bars, are obtainable in a grade of steel conforming to the specification of the American Society for Testing Materials designated as A. S. T. M.—A9, Structural Steel for Buildings. They are produced by one or more of the following subsidiary manufacturing companies: Carnegie Steel Company; Columbia Steel Company; Illinois Steel Company; Tennessee Coal, Iron & Railroad Company. The sales departments of any of these companies will accept orders for any of the structural sections listed.

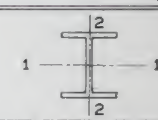
Pipe and Sheets. The steel pipe sections are produced by the National Tube Company; and the steel sheets by the American Sheet and Tin Plate Company, the Columbia Steel Company, and the Tennessee Coal, Iron & Railroad Company. The grades of steel conform to the standard specifications of these companies.

Corrosion. Any of the products listed are securable, upon special inquiry, in a grade of copper steel which, under most conditions, will retard corrosion.

WIDE FLANGE SECTIONS



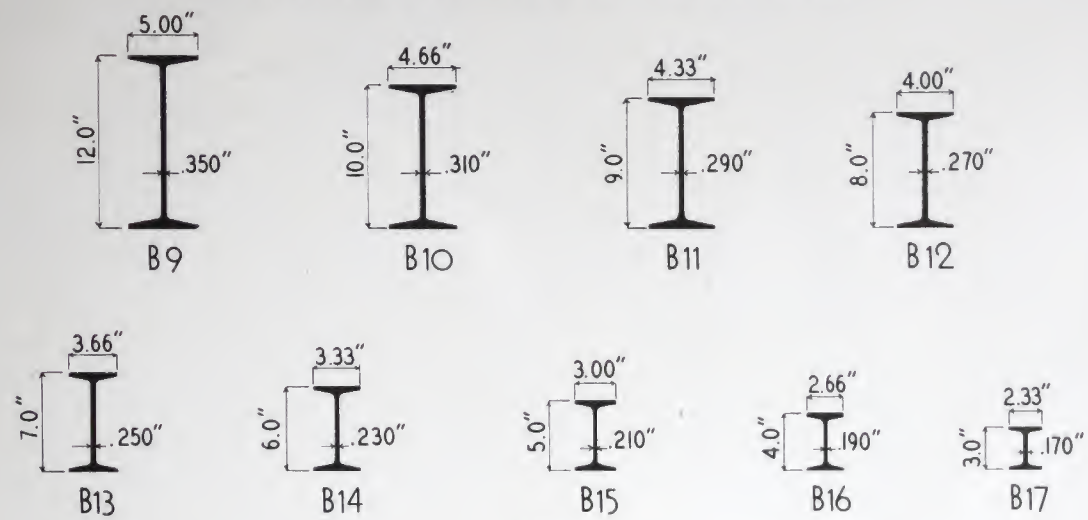
DIMENSIONS AND PROPERTIES OF SECTIONS



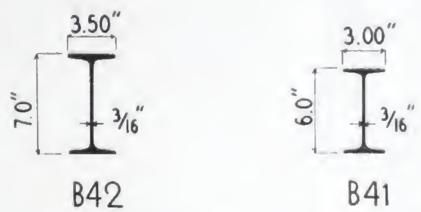
Section Number	Weight per ft.	Depth of Section	Flange		Web Thickness	Area of Section	Axis 1-1			Axis 2-2		
			Width	Mean Thickness			I	S	r	I	S	r
	Lb	In.	In.	In.	In.	In.²	In.⁴	In.³	In.	In.⁴	In.³	In.
WIDE FLANGE SECTIONS												
CB121	28	12	6½	7/16	¼	8.23	213.5	35.6	5.09	17.5	5.4	1.46
	25	11 7/8	6½	3/8	¼	7.39	183.4	30.9	4.98	14.5	4.5	1.40
CB101	21	9 7/8	5¾	5/16	¼	6.19	106.3	21.5	4.14	9.7	3.4	1.25
B39	17	8	5	5/16	3/16	5.00	57.2	14.3	3.38	6.0	2.4	1.09
CB102	33	9¾	8	7/16	5/16	9.71	170.9	35.0	4.20	36.5	9.2	1.94
CB 83	31	8	8	7/16	5/16	9.12	109.7	27.4	3.47	37.0	9.2	2.01
CB 82	24	7 15/16	6½	3/8	¼	7.06	82.5	20.8	3.42	18.2	5.6	1.61
CB61	40	5¾	9½	½	½	11.76	69.6	24.2	2.43	69.9	14.7	2.44
SMALL H SECTIONS												
H 3	20.0	6	5 15/16	3/8	¼	5.86	38.8	12.9	2.57	11.4	3.8	1.39
H 2	18.9	5	5	7/16	5/16	5.47	23.8	9.5	2.08	7.8	3.1	1.20
H 1	13.8	4	4	3/8	5/16	3.99	10.7	5.3	1.64	3.6	1.8	0.95

See page 33 for names of producing mills.

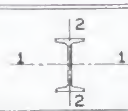
STANDARD BEAM SECTIONS



SPECIAL BEAM SECTIONS



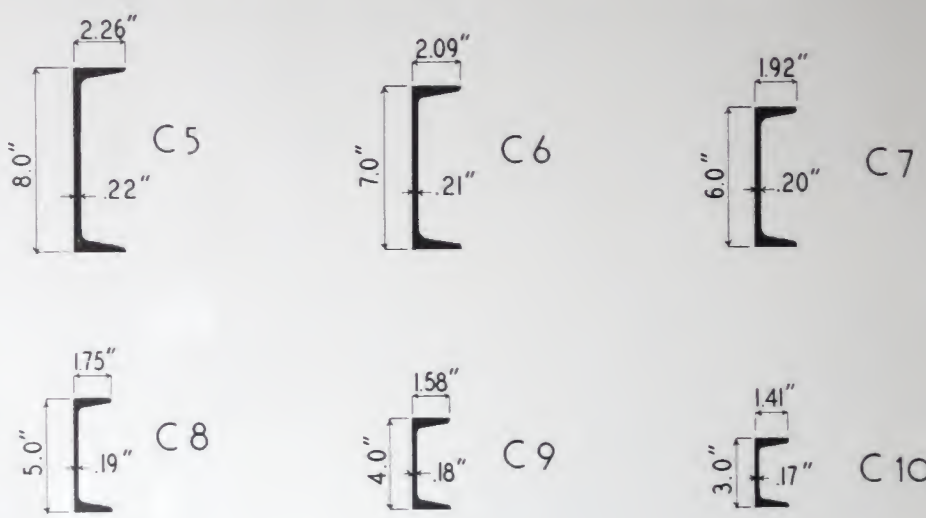
DIMENSIONS AND PROPERTIES OF SECTIONS



Section Number	Weight per ft.	Depth of Section	Flange Width	Flange Mean Thickness	Web Thickness	Area of Section	Axis 1-1 I	Axis 1-1 S	Axis 1-1 r	Axis 2-2 I	Axis 2-2 S	Axis 2-2 r
	Lb.	In.	In.	In.	In.	In.^{2}	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
B9	31.8	12	5	9/16	3/8	9.26	215.8	36.0	4.83	9.5	3.8	1.01
B10	25.4	10	4 11/16	1/2	5/16	7.38	122.1	24.4	4.07	6.9	3.0	0.97
B11	21.8	9	4 5/16	7/16	5/16	6.32	84.9	18.9	3.67	5.2	2.4	0.90
B12	18.4	8	4	7/16	1/4	5.34	56.9	14.2	3.26	3.8	1.9	0.84
B13	15.3	7	3 11/16	3/8	1/4	4.43	36.2	10.4	2.86	2.7	1.5	0.78
B14	12.5	6	3 5/16	3/8	1/4	3.61	21.8	7.3	2.46	1.8	1.1	0.72
B15	10.0	5	3	5/16	3/16	2.87	12.1	4.8	2.05	1.2	0.82	0.65
B16	7.7	4	2 11/16	5/16	3/16	2.21	6.0	3.0	1.64	0.77	0.58	0.59
B17	5.7	3	2 5/16	1/4	3/16	1.64	2.5	1.7	1.23	0.46	0.40	0.53
SPECIAL BEAM SECTIONS												
B42	12.0	7	3 1/2	5/16	3/16	3.52	29.8	8.5	2.91	2.1	1.18	0.77
B41	10.0	6	3	5/16	3/16	2.91	17.8	5.9	2.47	1.3	0.85	0.66

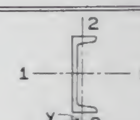
See page 33 for names of producing mills.

STANDARD CHANNEL SECTIONS



BAR CHANNEL SECTIONS

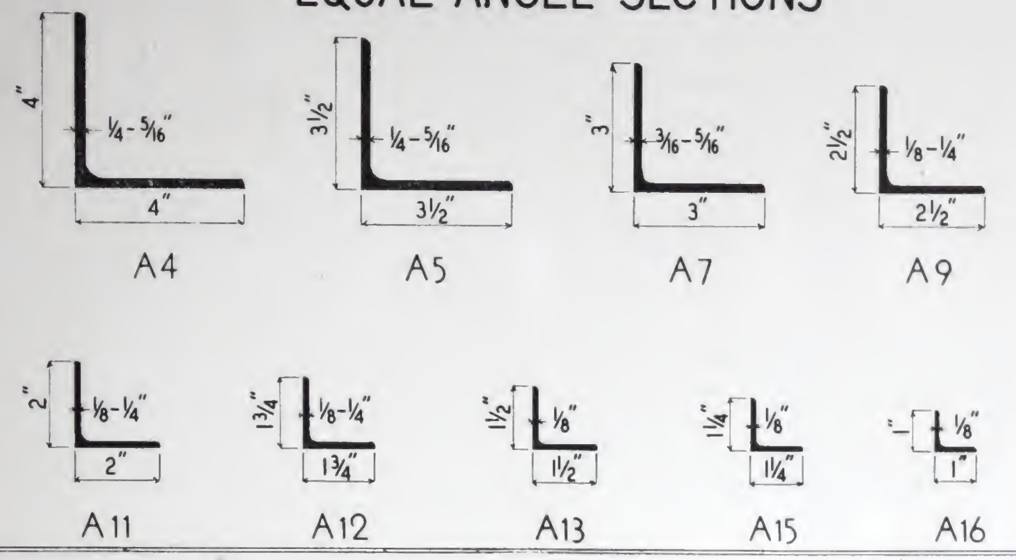
DIMENSIONS AND PROPERTIES OF SECTIONS



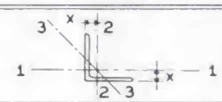
Section Number	Weight per ft.	Depth of Section	Flange		Web Thickness	Area of Section	Axis 1-1			Axis 2-2			
			Width	Mean Thickness			I	S	r	I	S	r	y
	Lb.	In.	In.	In.	In.	In.^{2}	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.	In.
STANDARD CHANNEL SECTIONS													
C 5	11.5	8	2¼	3/8	1/4	3.36	32.3	8.1	3.10	1.3	0.79	0.63	0.58
C 6	9.8	7	2 1/16	3/8	3/16	2.85	21.1	6.0	2.72	0.98	0.63	0.59	0.55
C 7	8.2	6	1 15/16	3/8	3/16	2.39	13.0	4.3	2.34	0.70	0.50	0.54	0.52
C 8	6.7	5	1¾	5/16	3/16	1.95	7.4	3.0	1.95	0.48	0.38	0.50	0.49
C 9	5.4	4	1 9/16	5/16	3/16	1.56	3.8	1.9	1.56	0.32	0.29	0.45	0.46
C10	4.1	3	1 7/16	1/4	3/16	1.19	1.6	1.1	1.17	0.20	0.21	0.41	0.44
BAR CHANNEL SECTIONS													
C 597	2.57	2	1	.234	3/16	0.756	0.42	0.42	0.75	0.07	0.106	0.30	0.35
C 598	1.78	2	1	.156	1/8	0.523	0.32	0.32	0.78	0.05	0.067	0.30	0.31

See page 33 for names of producing mills.

EQUAL ANGLE SECTIONS



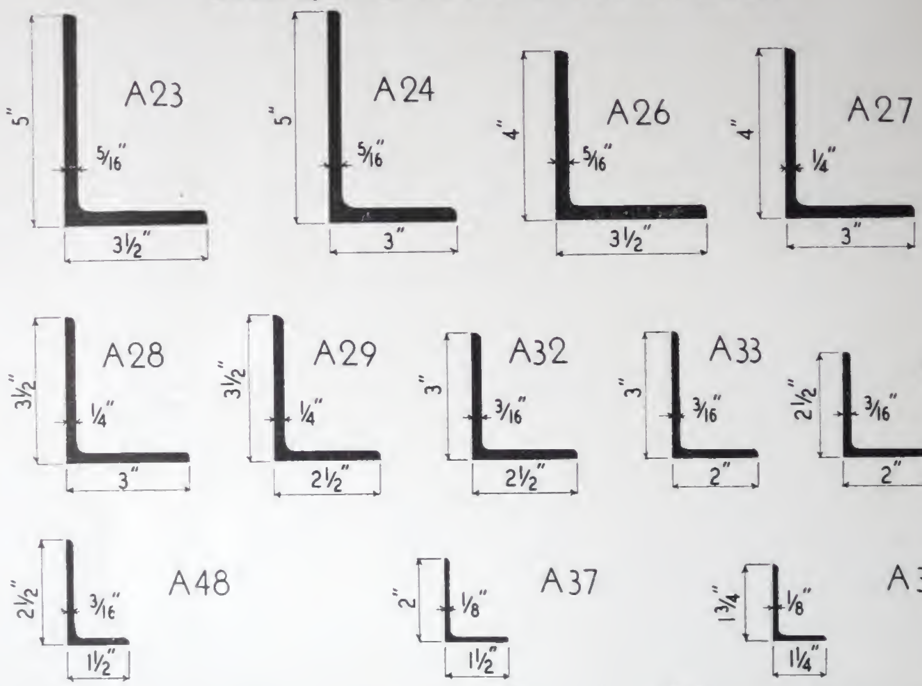
DIMENSIONS AND PROPERTIES OF SECTIONS



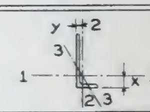
Section Number	Size	Thickness	Weight per ft.	Area of Section	Axis 1-1 and Axis 2-2				Axis 3-3
					I	S	r	x	$r_{min.}$
	In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.
A 4	4 × 4	5⁄16	8.2	2.40	3.7	1.3	1.24	1.12	0.79
		¼	6.6	1.94	3.0	1.0	1.25	1.09	0.79
A 5	3½ × 3½	5⁄16	7.2	2.09	2.5	0.98	1.08	0.99	0.69
		¼	5.8	1.69	2.0	0.79	1.09	0.97	0.69
A 7	3 × 3	5⁄16	6.1	1.78	1.5	0.71	0.92	0.87	0.59
		¼	4.9	1.44	1.2	0.58	0.93	0.84	0.59
		3⁄16	3.71	1.09	0.96	0.44	0.94	0.82	0.60
A 9	2½ × 2½	¼	4.1	1.19	0.70	0.39	0.77	0.72	0.49
		3⁄16	3.07	0.90	0.55	0.30	0.78	0.69	0.49
		⅛	2.08	0.61	0.38	0.20	0.79	0.67	0.50
A 11	2 × 2	¼	3.19	0.94	0.35	0.25	0.61	0.59	0.39
		3⁄16	2.44	0.71	0.28	0.19	0.62	0.57	0.40
		⅛	1.65	0.48	0.19	0.13	0.63	0.55	0.40
A 12	1¾ × 1¾	¼	2.77	0.81	0.23	0.19	0.53	0.53	0.34
		3⁄16	2.12	0.62	0.18	0.14	0.54	0.51	0.35
		⅛	1.44	0.42	0.13	0.10	0.55	0.48	0.35
A 13	1½ × 1½	⅛	1.23	0.36	0.08	0.07	0.46	0.42	0.30
A 15	1¼ × 1¼	⅛	1.01	0.30	0.04	0.05	0.38	0.35	0.25
A 16	1 × 1	⅛	0.80	0.23	0.02	0.03	0.31	0.30	0.19

See page 33 for names of producing mills.

UNEQUAL ANGLE SECTIONS



DIMENSIONS AND PROPERTIES OF SECTIONS

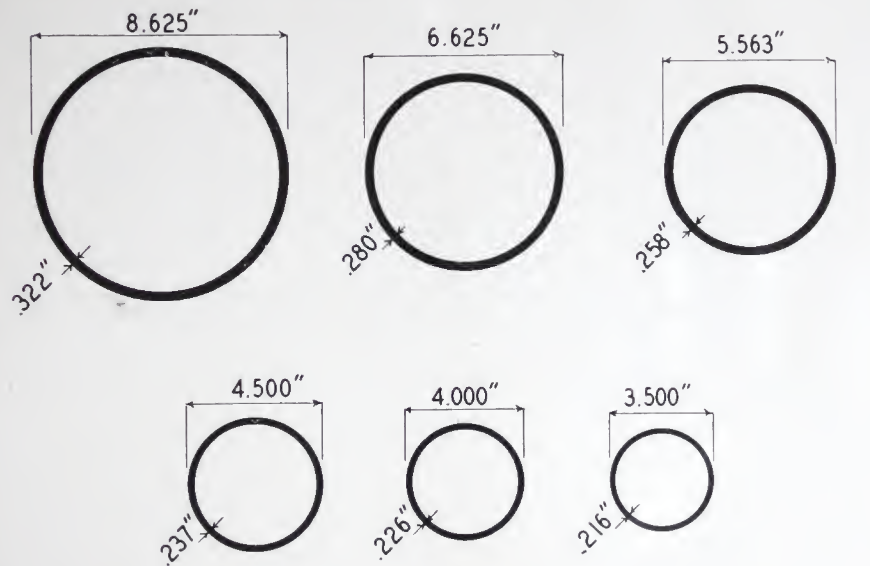


Section Number	Size	Thickness	Weight per ft.	Area of Section	Axis 1-1				Axis 2-2				Axis 3-3
					I	S	r	x	I	S	r	y	$r_{min.}$
	In.	In.	Lb.	$In.^2$	$In.^4$	$In.^3$	In.	In.	$In.^4$	$In.^3$	In.	In.	In.
A 23	5 × 3½	5/16	8.7	2.56	6.6	1.9	1.61	1.59	2.7	1.0	1.03	0.84	0.76
A 24	5 × 3	5/16	8.2	2.40	6.3	1.9	1.61	1.68	1.8	0.75	0.85	0.68	0.66
A 26	4 × 3½	5/16	7.7	2.25	3.6	1.3	1.26	1.18	2.6	1.0	1.07	0.93	0.73
A 27	4 × 3	¼	5.8	1.69	2.8	1.0	1.28	1.24	1.4	0.60	0.89	0.74	0.65
A 28	3½ × 3	¼	5.4	1.56	1.9	0.78	1.11	1.04	1.3	0.58	0.91	0.79	0.63
A 29	3½ × 2½	¼	4.9	1.44	1.8	0.75	1.12	1.11	0.78	0.41	0.74	0.61	0.54
A 32	3 × 2½	¼	4.5	1.31	1.2	0.56	0.95	0.91	0.74	0.40	0.75	0.66	0.53
		3/16	3.39	1.00	0.91	0.43	0.95	0.89	0.58	0.31	0.76	0.64	0.53
A 33	3 × 2	3/16	3.07	0.90	0.84	0.41	0.97	0.97	0.31	0.20	0.58	0.47	0.44
A 35	2½ × 2	3/16	2.75	0.81	0.51	0.29	0.79	0.76	0.29	0.20	0.60	0.51	0.43
A 48	2½ × 1½	3/16	2.44	0.72	0.46	0.28	0.80	0.85	0.13	0.11	0.42	0.35	0.33
A 37	2 × 1½	⅛	1.44	0.42	0.17	0.13	0.64	0.62	0.09	0.08	0.45	0.37	0.33
A 39	1¾ × 1¼	⅛	1.23	0.36	0.11	0.09	0.56	0.56	0.05	0.05	0.37	0.31	0.27

See page 33 for names of producing mills.

STEEL PIPE SECTIONS

NATIONAL STANDARD PIPE—BLACK OR GALVANIZED



DIMENSIONS AND PROPERTIES OF SECTIONS

Nominal Size	Outside Diameter	Thickness	Weight per ft.	Area of Metal	Any axis through center I	S	r
In.	In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.
8	8.625	0.322	28.55	8.40	72.5	16.8	2.94
6	6.625	0.280	18.97	5.58	28.1	8.50	2.25
5	5.563	0.258	14.61	4.30	15.2	5.45	1.88
4	4.500	0.237	10.79	3.17	7.23	3.21	1.51
3½	4.000	0.226	9.10	2.68	4.79	2.39	1.34
3	3.500	0.216	7.57	2.23	3.02	1.72	1.16

See page 33 for names of producing mills.

UNIVERSAL STEEL PLATES

Thickness In.	Weight Lbs. per Sq. Foot	WIDTHS IN INCHES								
		6 1/8	10	24	30	36	42	48	54	60
		MAXIMUM LENGTH IN INCHES								
3/16	7.65	960	960	960	....	....	....	....	....	....
1/4	10.20	960	1080	1080	1080	720	720	1200	840	780
5/16	12.75	960	1080	1200	1200	1200	1200	1200	1080	1000
3/8	15.30	960	1080	1200	1200	1200	1200	1320	1200	1080
7/16	17.85	960	1080	1200	1200	1200	1200	1428	1200	1080
1/2	20.40	960	1080	1200	1200	1200	1200	1440	1200	1080

Sizes not shown above may be furnished by special arrangement.

SHEARED STEEL PLATES

Thickness In.	Weight Lbs. per Sq. Foot	WIDTHS IN INCHES												
		24	30	36	42	48	54	60	66	72	78	84	90	96
		MAXIMUM LENGTH IN INCHES												
3/16	7.65	400	400	400	420	420	450	420	400	375	345	320	270	...
1/4	10.20	420	450	520	530	530	530	525	475	430	400	375	330	330
5/16	12.75	450	450	480	480	540	540	560	500	480	460	440	420	360
3/8	15.30	450	480	520	600	600	600	600	600	600	550	500	450	360
7/16	17.85	450	450	520	600	600	600	600	600	600	550	510	460	360
1/2	20.40	450	450	600	600	600	600	600	600	600	580	550	510	380

Sizes not shown above may be furnished by special arrangement.

See page 33 for names of producing mills.

HOT ROLLED STEEL STRIP

(Band Edge Flats and Hoops)

In straight 30 ft. lengths or in ribbon coils

Birmingham Wire Gage		Approximate Weight Lbs. per Sq. Foot	Range of Widths Inches	
Thickness In.	Gage No.		Minimum	Maximum
.025	23	1.020	3/8	2
.028	22	1.142	3/8	3½
.032	21	1.306	3/8	3½
.035	20	1.428	3/8	3½
.042	19	1.714	3/8	3½
.049	18	1.999	3/8	14
.058	17	2.366	3/8	16
.065	16	2.652	3/8	23 15/16
.072	15	2.938	3/8	23 15/16
.083	14	3.386	3/8	23 15/16
.095	13	3.876	3/8	23 15/16
.109	12	4.447	3/8	23 15/16
.120	11	4.896	3/8	23 15/16
.134	10	5.467	3/8	23 15/16
.148	9	6.038	7/16	23 15/16

Sizes not shown above may be furnished by special arrangement.

ANNEALED LOW CARBON STEEL SHEETS

Approximate Thickness Inches	United States Standard		Widths in Inches									
	Gage No.	Weight Lbs. per Sq. Foot	24	30	36	42	48	54	60	66	72	84
			Maximum Length in Inches									
.0123	30	.500	144	144	144	100	...	...	...	...	...	...
.0153	28	.625	144	144	144	120	...	...	...	...	...	...
.0184	26	.750	144	144	144	120	96	...	...	...	...	...
.0245	24	1.000	144	144	144	120	120	...	...	...	...	...
.0306	22	1.250	144	144	144	144	120	120	100	...	...	...
.0368	20	1.500	144	144	144	144	120	120	120	120	120	...
.0490	18	2.000	144	144	144	144	144	120	120	120	120	...
.0613	16	2.500	...	168	168	168	168	168	144	144	144	...
.0766	14	3.125	...	180	180	180	180	180	160	160	144	...
.1072	12	4.375	...	...	240	240	240	240	240	240	240	240
.1225	11	5.000	...	...	240	240	240	240	240	240	240	240
.1379	10	5.625	...	...	240	240	240	240	240	240	240	240
.1532	9	6.250	...	...	240	240	240	240	240	240	240	240
.1685	8	6.875	...	...	240	240	240	240	240	240	216	216
.1838	7	7.500	...	...	240	240	240	240	240	240	216	216

Sizes not shown above may be furnished by special arrangement.

See page 33 for names of producing mills.

Safe Loads for Sections used as Beams

Explanation of Tables. The tables of safe loads for structural steel I-beams and channels used as beams give the allowable uniformly distributed safe load in kips for a range of spans customary in residence construction. These loads are presented in two ways. The first value (large bold face type) is based upon a maximum bending stress of 18 kips per square inch. The second value (small light face type) is based on a maximum deflection, due to live load only, of 1/360 of the span. In addition, tables of safe loads are given for angles and small channels which, although not generally used as floor joists, may be subjected to loads producing bending. For these sections the tables give values for the conditions stated above for a span of one foot, from which the uniformly distributed safe load for any span may be obtained by direct division. They also give the safe load for the span at which a stress of 18 kips per sq. in. will produce a deflection of 1/360 of the span length.

It is assumed in all cases that the loads are normal to the major axis 1–1 (in residences loads are nearly always applied vertically) and that the member deflects only in the plane of loading. If, as sometimes happens in sloping roof construction, the condition involves the introduction of forces outside this plane of loading, the allowable safe loads must be determined from the general theory of flexure. This condition applies particularly in the case of unsymmetrical sections, such as angles, which should be used only under loading conditions where the section is rigidly secured against lateral deflection or twisting throughout the span.

For cases involving large concentrated loads, either alone or in combination with uniform loads, the strength of the required beam should also be determined from the general theory of flexure, or computed in accordance with the method given in the Carnegie-Illinois Pocket Companion, Abridged Edition, indexed under "Loading Conditions."

Lateral Bracing. In the construction of residences the compression flanges of floor beams must be secured against lateral deflection. This may be done by the floor filling, by bridging placed at proper intervals, or by other means. The tables given on pages 44 and 45 are based upon the assumption that the beams are adequately braced laterally.

Vertical Deflection. The deflection of floor beams carrying plastered ceilings should be limited to not more than 1/360 of the span length to avoid cracking of plaster. For spans to the left of the zig-zag line, the beam under the total load shown will not exceed the permissible deflection; for spans to the right of the zig-zag line, the total allowable bending stress load (bold face upper value) would under certain conditions, produce excessive deflection.

However, since plaster is usually applied after the dead weight of the floor construction is already on the beam, the only load that may cause plaster to crack will be the live load. Therefore, provided the live load does not exceed the value determined by deflection requirements (light face lower value), the beam will be satisfactory for carrying the larger total load as determined by the bending stress.

Since in residence construction it is improbable that the weight of the average floor construction will ever exceed the assumed live load, the values have been extended only to the span where the total load is twice the live load (namely, live and dead loads equal). This condition occurs when the span in feet is 3.58 times the depth of the section in inches.

EXAMPLES OF THE USE OF BEAM SAFE LOAD TABLES

Example (1) FLOOR JOIST

Required: The proper size of floor joists, 16 ft. span, to be spaced 3 ft. apart and laterally braced. The floor construction, including a plastered ceiling below, weighs 35 lb. per sq. ft., and the live load is 40 lb. per sq. ft.

Dead Load = 16 x 3 x 35 lb. = 1.68 kips
Live Load = 16 x 3 x 40 lb. = 1.92 kips

Total Load = 3.60 kips

See table on page 44. On a 16 ft. span, if an I-beam shape is not required, Channel C6, 7 in. deep, with $2\frac{1}{8}$ in. flange, weighing 9.8 lb. per ft., will support a total load of 4.5 kips of which 3.5 may be live load. If an I-beam is needed, Beam B15, 5 in. deep with 3 in. flange, weighing 10.0 lb. per ft., will support a total load of 3.6 kips of which 2.0 kips may be live load.

The deflection of either of these sections will be within the allowable limits for plastered ceilings.*

(Another example of this type is given on page 12, Typical Steps in Design.)

Example (2) ROOF JOIST

Required: The proper size of a section to support the roof of a two-car garage, on a 17′–6″ span. The members are to be spaced two feet apart and will support a dead load of 20 lb. per sq. ft. and a snow load of 25 lb. per sq. ft. Deflection may be disregarded.

Total Uniformly Distributed Load = 17.5 x 2 x (20 + 25) lb. = 1.58 kips.

From table on page 44 under 18 ft. span, it is found that Channel C8, 5 in. deep with $1\frac{3}{4}$ in. flange, weighing 6.7 lb. per ft., will support a total load of 2.0 kips.

*It has usually been found that for use as a joist, an I-beam is preferable to a channel on account of its symmetry and greater lateral stiffness.

Example (3) FLOOR GIRDER

Required: The proper size of a girder beam on a 14 ft. span, supporting a load as follows:

Floor Load = 900 lb. per lin. ft.
Partition Load = 315 lb. per lin. ft.

Combined Load = 1,215 lb. per lin. ft.
The Total Load = 14 x 1,215 lb. = 17.0 kips

In the table on page 44, it is found that Beam CB 101, 10 in. deep with $5\frac{3}{4}$ in. flange, weighing 21 lb. per ft., will support a total load of 18.4 kips. The net load (total load minus weight of beam) it will support is 18,400 – (14 x 21) = 18.1 kips, which is in excess of the actual load.

Example (4) ANGLE LINTEL

Required: The proper size of an angle on a 4 ft. span, supporting a load of 500 lb. per lin. ft. The minimum width of leg required is 3 inches.

The total load = 500 x 4 lb. = 2 kips.

The equivalent load for a 1 ft. span = 4 x 2 = 8 kips.

Referring to table on page 45, it is found that a 3 x 3 x $\frac{5}{16}$ in. angle, weighing 6.1 lb. per ft., would carry 8.52 kips on a 1 ft. span. A $3\frac{1}{2}$ x 3 x $\frac{1}{4}$ in. angle, with the $3\frac{1}{2}$ in. leg vertical, weighing 5.4 lb. per ft., would carry 9.36 kips on a 1 ft. span. Therefore either of these sections would be satisfactory.

Example (5) JOIST DEFLECTION

A 5 inch 10 lb. I-beam, B15, is used on a 15 ft. span. It supports a present dead load of 50 lb. per lin. ft., and a live load of 150 lb. per lin. ft. Required to determine whether a metal lath and plaster ceiling (which would add a dead load of 50 lb. per lin. ft. to the beam) can be added without fear of its cracking due to deflection of the beam.

Present Dead Load	= 50 x 15 =	750 lb.	
Contemplated Ceiling Load	= 50 x 15 =	750 lb.	
Total Dead Load		= 1,500 lb.	= 1.5 kips
Live Load	=150 x 15 =	2,250 lb.	= 2.25 "
Combined Dead and Live Load			= 3.75 kips

From the table on page 44, it is found that the beam will carry a total load of 3.8 kips, of which 2.3 kips is live, without exceeding the allowable deflection.

ALLOWABLE UNIFORM LOAD IN KIPS FOR SECTIONS USED AS BEAMS

MAXIMUM BENDING STRESS – 18 kips per square inch. Loads are for sections braced against lateral deflection. Excessive deflection will occur if live load exceeds value [light type] tabulated beneath total load [bold type].

SECTION	NUMBER	NOMINAL SIZE Depth In.	NOMINAL SIZE Flange In.	Weight per Foot Lb.	Section Modulus S_{1-1} In.^{3}	SPAN IN FEET 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WIDE FLANGE	CB121	12	6½	28	35.6				**69.1**	**61.0**	**53.4**	**47.5**	**42.7**	**38.8**	**35.6**	**32.9**	**30.5**	**28.5**	**26.7**	**25.1**	**23.7**	**22.5**	**21.4**	**20.3**
	CB121	12	6½	25	30.9			**68.4**	**61.8**	**53.0**	**46.4**	**41.2**	**37.1**	**33.7**	**30.9**	**28.5**	**26.5**	**24.7**	**23.2**	**21.8**	**20.6**	**19.5**	**18.5**	**17.7**
	CB101	10	5¾	21	21.5		**57.0**	**51.6**	**43.0**	**36.9**	**32.3**	**28.7**	**25.8**	**23.5**	**21.5**	**19.8**	**18.4**	**17.2**	**16.1**	**15.2**	**14.3** 14.1	**13.6** 12.7	**12.9** 11.4	**12.3** 10.4
	B39	8	5	17	14.3		**40.9**	**34.3**	**28.6**	**24.5**	**21.5**	**19.1**	**17.2**	**15.6**	**14.3**	**13.2**	**12.3**	**11.4** 10.9	**10.7** 9.6	**10.1** 8.5	**9.5** 7.6	**9.0** 6.8	**8.6** 6.1	**8.2** 5.6
STANDARD BEAM	B9	12	5	31.8	36.0		**100.8**	**86.4**	**72.0**	**61.7**	**54.0**	**48.0**	**43.2**	**39.3**	**36.0**	**33.2**	**30.9**	**28.8**	**27.0**	**25.4**	**24.0**	**22.7**	**21.6**	**20.6**
	B10	10	4⅝	25.4	24.4	**74.4**	**73.2**	**58.6**	**48.8**	**41.9**	**36.6**	**32.5**	**29.3**	**26.6**	**24.4**	**22.5**	**20.9**	**19.5**	**18.3**	**17.2**	**16.3** 16.2	**15.4** 14.5	**14.6** 13.1	**13.9** 11.9
	B11	9	4⅜	21.8	18.9	**62.6**	**56.7**	**45.4**	**37.8**	**32.4**	**28.4**	**25.2**	**22.7**	**20.6**	**18.9**	**17.4**	**16.2**	**15.1**	**14.2**	**13.3** 12.6	**12.6** 11.3	**11.9** 10.1	**11.3** 9.1	**10.8** 8.3
	B12	8	4	18.4	14.2	**51.6**	**42.6**	**34.1**	**28.4**	**24.3**	**21.3**	**18.9**	**17.0**	**15.5**	**14.2**	**13.1**	**12.2**	**11.4** 10.9	**10.7** 9.5	**10.0** 8.5	**9.5** 7.5	**9.0** 6.8	**8.5** 6.1	**8.1** 5.5
	B13	7	3⅝	15.3	10.4	**41.6**	**31.2**	**25.0**	**20.8**	**17.8**	**15.6**	**13.9**	**12.5**	**11.4**	**10.4**	**9.6** 9.2	**8.9** 7.9	**8.3** 6.9	**7.8** 6.1	**7.3** 5.4	**6.9** 4.8	**6.6** 4.3	**6.2** 3.9	**5.9** 3.5
	B14	6	3⅜	12.5	7.3	**29.2**	**21.9**	**17.5**	**14.6**	**12.5**	**11.0**	**9.7**	**8.8**	**8.0** 7.7	**7.3** 6.5	**6.7** 5.5	**6.3** 4.8	**5.8** 4.2	**5.5** 3.7	**5.2** 3.2	**4.9** 2.9	**4.6** 2.6	**4.4** 2.3	**4.2** 2.1
	B15	5	3	10.0	4.8	**19.2**	**14.4**	**11.5**	**9.6**	**8.2**	**7.2**	**6.4** 6.4	**5.8** 5.2	**5.2** 4.3	**4.8** 3.6	**4.4** 3.1	**4.1** 2.7	**3.8** 2.3	**3.6** 2.0	**3.4** 1.8	**3.2** 1.6			
	B16	4	2⅝	7.7	3.0	**12.0**	**9.0**	**7.2**	**6.0**	**5.1**	**4.5** 4.0	**4.0** 3.2	**3.6** 2.6	**3.3** 2.1	**3.0** 1.8	**2.8** 1.5	**2.6** 1.3							
	B17	3	2⅜	5.7	1.7	**6.8**	**5.1**	**4.1**	**3.4** 3.0	**2.9** 2.2	**2.6** 1.7	**2.3** 1.3	**2.0** 1.1	**1.9** 0.9										
SPECIAL BEAM	B42	7	3½	12.0	8.5	**31.5**	**25.5**	**20.4**	**17.0**	**14.6**	**12.8**	**11.3**	**10.2**	**9.3**	**8.5**	**7.8** 7.6	**7.3** 6.5	**6.8** 5.7	**6.4** 5.0	**6.0** 4.4	**5.7** 4.0	**5.4** 3.6	**5.1** 3.2	**4.9** 2.9
	B41	6	3	10.0	5.9	**23.6**	**17.7**	**14.2**	**11.8**	**10.1**	**8.9**	**7.9**	**7.1**	**6.4** 6.3	**5.9** 5.3	**5.4** 4.5	**5.1** 3.9	**4.7** 3.4	**4.4** 3.0	**4.2** 2.7	**3.9** 2.4	**3.7** 2.1	**3.5** 1.9	**3.4** 1.7
STANDARD CHANNEL	C5	8	2¼	11.5	8.1	**32.4**	**24.3**	**19.4**	**16.2**	**13.9**	**12.2**	**10.8**	**9.7**	**8.8**	**8.1**	**7.5**	**6.9**	**6.5** 6.2	**6.1** 5.4	**5.7** 4.8	**5.4** 4.3	**5.1** 3.8	**4.9** 3.5	**4.6** 3.1
	C6	7	2⅛	9.8	6.0	**24.0**	**18.0**	**14.4**	**12.0**	**10.3**	**9.0**	**8.0**	**7.2**	**6.5**	**6.0**	**5.5** 5.4	**5.1** 4.6	**4.8** 4.0	**4.5** 3.5	**4.2** 3.1	**4.0** 2.8	**3.8** 2.5	**3.6** 2.3	**3.4** 2.1
	C7	6	1⅞	8.2	4.3	**17.2**	**12.9**	**10.3**	**8.6**	**7.4**	**6.5**	**5.7**	**5.2**	**4.7** 4.6	**4.3** 3.9	**4.0** 3.3	**3.7** 2.8	**3.4** 2.5	**3.2** 2.2	**3.0** 1.9	**2.9** 1.7	**2.7** 1.5	**2.6** 1.4	**2.5** 1.3
	C8	5	1¾	6.7	3.0	**12.0**	**9.0**	**7.2**	**6.0**	**5.1**	**4.5**	**4.0** 3.9	**3.6** 3.2	**3.3** 2.6	**3.0** 2.2	**2.8** 1.9	**2.6** 1.6	**2.4** 1.4	**2.3** 1.2	**2.1** 1.1	**2.0** 1.0			
	C9	4	1⅝	5.4	1.9	**7.6**	**5.7**	**4.6**	**3.8**	**3.3**	**2.9** 2.6	**2.5** 2.0	**2.3** 1.6	**2.1** 1.3	**1.9** 1.1	**1.8** 1.0	**1.6** 0.8							
	C10	3	1⅜	4.1	1.1	**4.4**	**3.3**	**2.6**	**2.2** 1.9	**1.9** 1.4	**1.7** 1.1	**1.5** 0.8	**1.3** 0.7	**1.2** 0.6										
SPAN IN FEET						3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

ALLOWABLE UNIFORM LOAD IN KIPS FOR SECTIONS USED AS BEAMS

EQUAL ANGLES

Neutral Axis parallel to either leg

SECTION NUMBER	SIZE	Weight per ft.	One Foot Span	Maximum Span equals 360 × Allowable Deflection	
	In.	Lb.	Safe Load	Total Safe Load	Length - Feet
A4	4 × 4 × 5/16	8.2	15.48	1.50	10.3
	1/4	6.6	12.60	1.21	10.4
A5	3½ × 3½ × 5/16	7.2	11.76	1.31	9.0
	1/4	5.8	9.48	1.05	9.1
A7	3 × 3 × 5/16	6.1	8.52	1.12	7.6
	1/4	4.9	6.96	0.90	7.7
	3/16	3.71	5.28	0.68	7.8
A9	2½ × 2½ × 1/4	4.1	4.68	0.74	6.4
	3/16	3.07	3.60	0.55	6.5
	1/8	2.08	2.40	0.37	6.6
A11	2 × 2 × 1/4	3.19	3.00	0.59	5.1
	3/16	2.44	2.28	0.45	5.1
	1/8	16.5	1.56	0.30	5.2
A12	1¾ × 1¾ × 1/4	2.77	2.28	0.52	4.4
	3/16	2.12	1.68	0.38	4.4
	1/8	1.44	1.20	0.26	4.6
A13	1½ × 1½ × 1/8	1.23	0.86	0.22	3.9
A15	1¼ × 1¼ × 1/8	1.01	0.59	0.18	3.2
A16	1 × 1 × 1/8	0.80	0.37	0.15	2.5

UNEQUAL ANGLES

Neutral Axis parallel to shorter leg

SECTION NUMBER	SIZE	Weight per ft.	One Foot Span	Maximum Span equals 360 × Allowable Deflection	
	In.	Lb.	Safe Load	Total Safe Load	Length-Feet
A23	5 × 3½ × 5/16	8.7	23.28	1.91	12.2
A24	5 × 3 × 5/16	8.2	22.68	1.91	11.9
A26	4 × 3½ × 5/16	7.7	15.12	1.50	10.1
A27	4 × 3 × 1/4	5.8	12.00	1.22	9.9
A28	3½ × 3 × 1/4	5.4	9.36	1.06	8.8
A29	3½ × 2½ × 1/4	4.9	9.00	1.05	8.6
A32	3 × 2½ × 1/4	4.5	6.72	0.90	7.5
	3/16	3.39	5.16	0.68	7.6
A33	3 × 2 × 3/16	3.07	4.92	0.67	7.3
A35	2½ × 2 × 3/16	2.75	3.48	0.56	6.2
A48	2½ × 1½ × 3/16	2.44	3.36	0.57	5.9
A37	2 × 1½ × 1/8	1.44	1.50	0.30	4.9
A39	1¾ × 1¼ × 1/8	1.23	1.13	0.27	4.3

BAR CHANNELS

Neutral Axis parallel to flanges

SECTION NUMBER	Depth	Flange	Weight per ft.			
	In.	In.	Lb.			
C597	2	1	2.57	5.09	1.42	3.6
C598	2	1	1.78	3.79	1.06	3.6

MAXIMUM BENDING STRESS – 18 kips per square inch. Loads are for sections braced against lateral deflection. For spans other than one foot, but less than the maximum tabulated above, the total uniformly distributed load may be found by dividing the safe load for the one foot span by the length of the given span, in feet.

Safe Loads for Sections used as Columns or Studs

Basis of Computation

The tables of allowable loads on steel column sections have been computed as follows:

For ratios of l/r up to 200: in accordance with the formula for steel columns of the American Institute of Steel Construction, Standard Specification, 1923, Revised 1928.

$$*f = \frac{18{,}000}{1 + \frac{1}{18{,}000}(l/r)^2}$$ with maximum unit stress (at l/r = 60) of 15,000 lb. (15 kips) per sq. in.

For ratios of l/r from 200 to 300: in accordance with the formula for a straight line tangent to the A. I. S. C. curve at the point l/r = 200, which in rounded form is

$$*f = 13{,}300 - 38.5\ (l/r)$$

*f = safe load in lb. per sq. in.

Explanation of Tables

The tables on pages 48 to 51 give the safe concentric load in kips for a selected range of steel sections suitable for residence construction. The tables on pages 34 to 39 give the radii of gyration about both axes of symmetry for use in other compression formulas which may be required by local building regulations.

The upper table on each page gives the allowable compression loads on columns or studs that are unbraced on either axis for the lengths shown at the top of the table. For columns, only the loads to the left of the solid zig-zag line should be used. For studs as loaded in the completed structure, only the loads to the left of the broken zig-zag line (including those to the left of the solid zig-zag line) should be used. For studs as loaded during construction, the loads in any part of the table may be used.

The lower table on each page gives in bold face type the allowable compression loads on studs under any condition of loading when their unbraced length on the major axis is that shown at the top of the upper table, provided they are braced on their minor axis at intervals not exceeding those shown in small type above each load. These intervals are the spacing that will make the stud of equal strength on either axis. They are obtained for each length by multiplying that length by the ratio $\frac{r_2}{r_1}$, or $\frac{r_3}{r_1}$, whichever the case may require.

The loading conditions are based on the following table:

USE		Value of Least l/r	Table	Location
Column	Any	Up to 120	Upper	To left of solid zig-zag line
Stud for Walls and Partitions	Permanently free-standing. Unbraced along either axis	Up to 200	Upper	To left of broken zig-zag line
	Permanently braced along minor axis by anchorage to enveloping wall materials	Up to 200	Lower	Any
	Temporarily unbraced. During construction only	Between 200 and 300	Upper	Any

As is indicated above, steel compression members, when adequately braced on their minor axis at intervals not exceeding those given in the tables, may be subjected to loads corresponding to those for the major axis. In all the cases tabulated these loads correspond with a slenderness ratio of less than 200, and will consequently conform to all local regulations that are based on the column formula of the American Institute of Steel Construction.

The following table gives the allowable unit stress per sq. in. for ratios of l/r from 60 to 300. Intermediate values may be found by interpolation.

COLUMNS		STUDS FOR WALLS AND PARTITIONS							
		AFTER COMPLETION				DURING CONSTRUCTION			
Ratio l/r	Unit Stress Kips per Sq. In.	Ratio l/r	Unit Stress Kips per Sq. In.	Ratio l/r	Unit Stress Kips per Sq. In.	Ratio l/r	Unit Stress Kips per Sq. In.	Ratio l/r	Unit Stress Kips per Sq. In.
Up to 60	15.00	122	9.85	162	7.32	202	5.52	252	3.60
62	14.83	124	9.71	164	7.22	204	5.45	254	3.52
64	14.66	126	9.56	166	7.11	206	5.37	256	3.44
66	14.49	128	9.42	168	7.01	208	5.29	258	3.37
68	14.32	130	9.28	170	6.91	210	5.22	260	3.29
70	14.15	132	9.15	172	6.81	212	5.14	262	3.21
72	13.98	134	9.01	174	6.71	214	5.06	264	3.14
74	13.80	136	8.88	176	6.62	216	4.98	266	3.06
76	13.63	138	8.75	178	6.52	218	4.91	268	2.98
78	13.45	140	8.62	180	6.43	220	4.83	270	2.91
80	13.28	142	8.49	182	6.34	222	4.75	272	2.83
82	13.11	144	8.36	184	6.25	224	4.68	274	2.75
84	12.93	146	8.24	186	6.16	226	4.60	276	2.67
86	12.76	148	8.12	188	6.07	228	4.52	278	2.60
88	12.59	150	8.00	190	5.99	230	4.45	280	2.52
90	12.41	152	7.88	192	5.91	232	4.37	282	2.44
92	12.24	154	7.77	194	5.82	234	4.29	284	2.37
94	12.07	156	7.65	196	5.74	236	4.21	286	2.29
96	11.91	158	7.54	198	5.66	238	4.14	288	2.21
98	11.74	160	7.43	200	5.59	240	4.06	290	2.14
100	11.57					242	3.98	292	2.06
102	11.41					244	3.91	294	1.98
104	11.24					246	3.83	296	1.90
106	11.08					248	3.75	298	1.83
108	10.92					250	3.68	300	1.75
110	10.76								
112	10.61								
114	10.45								
116	10.30								
118	10.15								
120	10.00								

See page 5 for distinction between columns and studs.

EXAMPLES OF THE USE OF COLUMN SAFE LOAD TABLES

Example (1) STUD IN BRICK VENEER WALL

Required: The proper size of a typical wall stud, 9′—6″ long, in a brick veneer residence. The typical stud carries 4.5 kips during construction and 14.0 kips after completion. The average spacing between studs is 4′—0″. The requirements of construction for this residence limit the depth to a maximum of 4 inches.

To provide for horizontal forces, the rule given on page 7 will be followed. A stud will be selected that is at least 3 in. deep, and the bending factor to be added will be 1.3 kip for each foot of wall surface between studs, or 5.2 kips. The total load, therefore, is 14.0 + 5.2 = 19.2 kips.

From the lower table on page 49 it is found, for studs 10 ft. long, that a 3 in. I-beam, weighing 5.7 lb. per ft., when braced along its minor axis at intervals not exceeding 51 inches, will carry a total load of 19.3 kips, and from the upper table that it will support a construction load of 7.5 kips. An alternative section would be a 4 in. channel weighing 5.4 lb. per ft. which will support a construction load of 4.7 kips and, when braced along its minor axis at intervals not exceeding 34 inches, will carry a total load of 21.1 kips.

Example (2) FRAMING NOT SUBJECT TO HORIZONTAL FORCES

Required: The proper size of a strut, 5 ft. long, so located that it cannot be subjected to lateral flexure. The total load it is required to support is 10.0 kips.

From the upper table on page 51, in the column for members 5 ft. long and considering only values to left of dotted zig-zag line, it is found that Angle A-32, 3 x 2½ x 3/16″ weighing 3.39 lb. per ft. will support a load of 10.5 kips when unbraced on either axis.

Example (3) BASEMENT COLUMN SUPPORTING UPPER FLOORS

Required: The proper size of a basement column, 10 ft. long, to support a total load of 52.0 kips.

From the upper table on page 49, considering only values to left of solid zig-zag line, it is found that Section H2, 5 x 5″ H-beam column, weighing 18.9 lb. per ft., will carry a load of 63.3 kips on a 10 ft. length, when unbraced on either axis.

If a steel pipe column is preferred it will be noted from the table on this page that a 5 in. standard pipe, weighing 14.61 lb. per ft., would be more than adequate.

ALLOWABLE LOAD IN KIPS ON STEEL PIPE SECTIONS USED AS COLUMNS

NOMINAL SIZE	OUTSIDE DIAMETER	Weight per foot	UNIT STRESS - Am. Institute of Steel Construction - 1928							
			EFFECTIVE LENGTH OF COLUMN - FEET							
In.	In.	Lb.	5	6	7	8	9	10	11	12
8	8.625	28.55							126.0	126.0
6	6.625	18.97						83.7	83.7	81.8
5	5.563	14.61				64.5	64.5	63.1	60.7	58.3
4	4.500	10.79		47.6	47.6	46.7	44.5	42.3	40.1	38.0
3½	4.000	9.10	40.2	40.2	39.6	37.5	35.4	33.3	31.3	29.3
3	3.500	7.57	33.4	33.1	31.1	29.1	27.1	25.2	23.4	21.7

ALLOWABLE LOAD IN KIPS ON SECTIONS USED AS COLUMNS OR STUDS

UNIT STRESS – American Institute of Steel Construction – 1928 to $l/r = 200$ $(13.3 - .0385\ l/r)$ for l/r between 200 and 300.

BRACING CONDITION		SECTION NUMBER	NOMINAL SIZE Depth In.	NOMINAL SIZE Flange In.	Weight per foot Lb.	EFFECTIVE LENGTH OF COLUMN – FEET 1½	2	2½	3	4	5	6	7	8	9	10	11	12
UNBRACED COLUMN OR STUD	WIDE FLANGE	CB102	10	8	33										145.7	144.2	139.2	134.0
		CB83	8	8	31											136.8	132.1	127.5
		CB82	8	6½	24									105.9	101.6	97.1	92.5	88.0
		CB61	5¾	9½	40												176.4	176.4
	SMALL H	H3	6	6	20								87.7	83.4	79.0	74.6	70.3	66.1
		H2	5	5	18.9							82.1	77.4	72.6	67.9	63.3	58.9	54.7
		H1	4	4	13.8					59.9	58.8	54.4	50.1	45.8	41.8	38.1	34.7	31.5
	STANDARD BEAM	B14	6	3⅜	12.5				54.2	52.1	46.9	41.8	37.0	32.7	28.9	25.5	22.6	20.2
		B15	5	3	10.0				43.1	39.7	35.1	30.7	26.8	23.4	20.4	17.9	15.7	13.7
		B16	4	2⅝	7.7			33.2	33.0	29.1	25.3	21.8	18.7	16.1	13.9	12.1	10.4	8.6
		B17	3	2⅜	5.7			24.6	23.5	20.3	17.2	14.6	12.3	10.5	8.9	7.5	6.1	4.7
	SPECIAL BEAM	B42	7	3½	12.0				52.8	52.5	47.4	42.7	38.1	34.0	30.3	27.0	24.1	21.5
		B41	6	3	10.0				43.7	40.5	35.9	31.5	27.6	24.1	21.1	18.5	16.3	14.3
	STANDARD CHANNEL	C9	4	1⅝	5.4		23.4	22.5	20.7	17.2	14.1	11.6	9.6	7.9	6.3	4.7	3.1	
		C10	3	1½	4.1		17.9	16.5	15.0	12.2	9.8	7.9	6.4	5.1	3.8	2.4		
	BAR CHANNEL	C597	2	1	2.57	11.4	10.1	8.8	7.6	5.6	4.2	3.1	1.9					
		C598	2	1	1.78	7.8	6.9	6.0	5.2	3.9	2.9	2.1	1.3					
						Loads to left of solid zig-zag line to be used for columns. Loads to left of broken zig-zag line to be used for studs in the completed structure. Loads in any part of table may be used for studs during construction.												
STUD BRACED ON MINOR AXIS AT INTERVALS GIVEN ABOVE EACH LOAD	WIDE FLANGE	CB102	10	8	33											116" 145.7	116" 145.7	116" 145.7
		CB83	8	8	31											120" 136.8	120" 136.8	120" 136.8
		CB82	8	6½	24									96" 105.9	96" 105.9	96" 105.9	96" 105.9	96" 105.9
		CB61	5¾	9½	40												176.4	176.4
	SMALL H	H3	6	6	20								83" 87.7	83" 87.7	83" 87.7	83" 87.7	83" 87.7	83" 87.7
		H2	5	5	18.9							72" 82.1	72" 82.1	72" 82.1	72" 82.1	72" 82.1	76" 80.5	83" 77.8
		H1	4	4	13.8					59.9	57" 59.9	57" 59.9	57" 59.9	57" 59.9	62" 57.9	69" 55.4	76" 52.8	83" 50.3
	STANDARD BEAM	B14	6	3⅜	12.5				54.2	43" 54.2	43" 54.2	43" 54.2	43" 54.2	43" 54.2	43" 54.2	43" 54.2	43" 54.2	43" 54.2
		B15	5	3	10.0				43.1	39" 43.1	39" 43.1	39" 43.1	39" 43.1	39" 43.1	39" 43.1	39" 43.1	41" 42.0	45" 40.5
		B16	4	2⅝	7.7			33.2	35" 33.2	35" 33.2	35" 33.2	35" 33.2	35" 33.2	35" 33.2	38" 32.1	43" 30.7	47" 29.3	51" 27.9
		B17	3	2⅜	5.7			24.6	31" 24.6	31" 24.6	31" 24.6	31" 24.6	36" 23.4	41" 22.1	46" 20.7	51" 19.3	56" 18.0	62" 16.8
	SPECIAL BEAM	B42	7	3½	12.0				52.8	46" 52.8	46" 52.8	46" 52.8	46" 52.8	46" 52.8	46" 52.8	46" 52.8	46" 52.8	46" 52.8
		B41	6	3	10.0				43.7	40" 43.7	40" 43.7	40" 43.7	40" 43.7	40" 43.7	40" 43.7	40" 43.7	40" 43.7	40" 43.7
	STANDARD CHANNEL	C9	4	1⅝	5.4		23.4	23.4	27" 23.4	27" 23.4	27" 23.4	27" 23.4	27" 23.4	27" 23.2	31" 22.2	34" 21.1	38" 20.1	
		C10	3	1½	4.1		17.9	24" 17.9	24" 17.9	24" 17.9	24" 17.9	25" 17.7	29" 16.7	33" 15.6	37" 14.5	42" 13.5		
	BAR CHANNEL	C597	2	1	2.57	18" 11.4	18" 11.4	18" 11.4	18" 11.4	19" 11.1	24" 10.1	28" 9.0	33" 8.1					
		C598	2	1	1.78	18" 7.8	18" 7.8	18" 7.8	18" 7.8	18" 7.7	23" 7.0	27" 6.4	32" 5.7					
EFFECTIVE LENGTH OF COLUMN – FEET						1½	2	2½	3	4	5	6	7	8	9	10	11	12

ALLOWABLE LOAD IN KIPS ON SECTIONS USED AS COLUMNS OR STUDS

UNIT STRESS - American Institute of Steel Construction - 1928 to l/r = 200 $(13.3 - .0385\ l/r)$ for l/r between 200 and 300.

BRACING CONDITION	SECTION	NUMBER	SIZE In.	Weight per foot Lb.	1½	2	2½	3	4	5	6	7	8	9	10	11	12
					EFFECTIVE LENGTH OF COLUMN - FEET												
UNBRACED COLUMN OR STUD	EQUAL ANGLES	A4	4 × 4 × 5/16	8.2				36.0	35.9	32.7	29.6	26.5	23.7	21.2	18.9	16.9	15.2
			1/4	6.6				29.1	29.1	26.4	23.9	21.4	19.2	17.1	15.3	13.7	12.3
		A5	3 1/2 × 3 1/2 × 5/16	7.2				31.4	29.6	26.5	23.4	20.6	18.1	15.9	14.0	12.4	11.0
			1/4	5.8				25.4	24.0	21.4	19.0	16.7	14.7	12.9	11.3	10.0	8.9
		A7	3 × 3 × 1/4	4.9			21.6	21.5	19.0	16.5	14.2	12.2	10.5	9.1	7.9	6.7	5.6
			3/16	3.71				16.4	14.5	12.6	10.9	9.4	8.1	7.0	6.1	5.3	4.4
		A9	2 1/2 × 2 1/2 × 3/16	3.07		13.5	13.4	12.5	10.6	8.8	7.4	6.2	5.2	4.3	3.5	2.6	1.8
			1/8	2.08			9.2	8.5	7.3	6.1	5.1	4.3	3.6	3.0	2.5	1.9	1.3
		A11	2 × 2 × 3/16	2.44		10.7	9.7	8.8	7.1	5.7	4.6	3.7	2.9	2.1	1.2		
			1/8	1.65		7.2	6.6	6.0	4.8	3.8	3.1	2.5	1.9	1.4	0.8		
		A12	1 3/4 × 1 3/4 × 3/16	2.12	9.3	8.8	7.9	7.0	5.5	4.2	3.3	2.5	1.7				
			1/8	1.44	6.3	6.0	5.4	4.8	3.7	2.9	2.3	1.7	1.2				
		A13	1 1/2 × 1 1/2 × 1/8	1.23	5.4	4.8	4.2	3.6	2.7	2.0	1.5	0.9					
		A15	1 1/4 × 1 1/4 × 1/8	1.01	4.2	3.6	3.0	2.5	1.8	1.2	0.7						
		A16	1 × 1 × 1/8	0.80	2.8	2.2	1.7	1.4	0.8								
					Loads to left of solid zig-zag line to be used for columns. Loads to left of broken zig-zag line to be used for studs in the completed structure. Loads in any part of table may be used for studs during construction.												
STUD BRACED ON MINOR AXIS AT INTERVALS GIVEN ABOVE EACH LOAD	EQUAL ANGLES	A4	4 × 4 × 5/16	8.2				36.0	47″ 36.0	47″ 36.0	47″ 36.0	53″ 34.4	61″ 32.4	68″ 30.4	76″ 28.4	84″ 26.5	91″ 24.7
			1/4	6.6				29.1	47″ 29.1	47″ 29.1	47″ 29.1	53″ 27.9	60″ 26.4	68″ 24.7	75″ 23.1	83″ 21.6	91″ 20.1
		A5	3 1/2 × 3 1/2 × 5/16	7.2				31.4	41″ 31.4	41″ 31.4	46″ 30.2	53″ 28.2	61″ 26.1	68″ 24.2	76″ 22.3	84″ 20.6	92″ 18.9
			1/4	5.8				25.4	41″ 25.4	41″ 25.4	45″ 24.5	53″ 22.9	60″ 21.3	68″ 19.3	75″ 18.2	83″ 16.8	91″ 15.5
		A7	3 × 3 × 1/4	4.9			21.6	35″ 21.6	35″ 21.6	38″ 21.1	45″ 19.4	53″ 17.8	60″ 16.3	68″ 14.8	76″ 13.5	83″ 12.2	91″ 11.1
			3/16	3.71				36″ 16.4	36″ 16.4	38″ 16.0	45″ 14.8	53″ 13.6	61″ 12.4	68″ 11.3	76″ 10.3	84″ 9.4	91″ 8.5
		A9	2 1/2 × 2 1/2 × 3/16	3.07		13.5	29″ 13.5	29″ 13.5	30″ 13.4	37″ 12.2	45″ 11.0	52″ 9.9	60″ 8.8	67″ 7.8	75″ 7.0	82″ 6.3	90″ 5.6
			1/8	2.08			30″ 9.2	30″ 9.2	30″ 9.1	37″ 8.3	45″ 7.5	53″ 6.7	60″ 6.0	68″ 5.4	75″ 4.8	83″ 4.3	91″ 3.9
		A11	2 × 2 × 3/16	2.44		24″ 10.7	24″ 10.7	24″ 10.7	30″ 9.6	38″ 8.4	46″ 7.3	54″ 6.3	61″ 5.5	69″ 4.8	77″ 4.1		
			1/8	1.65		24″ 7.2	24″ 7.2	24″ 7.2	30″ 6.5	38″ 5.7	45″ 5.0	53″ 4.3	60″ 3.8	68″ 3.3	76″ 2.9		
		A12	1 3/4 × 1 3/4 × 3/16	2.12	9.3	21″ 9.3	21″ 9.3	23″ 8.9	31″ 7.8	38″ 6.6	46″ 5.6	54″ 4.8	62″ 4.0				
			1/8	1.44	6.3	21″ 6.3	21″ 6.3	22″ 6.1	30″ 5.3	38″ 4.6	45″ 3.9	53″ 3.3	61″ 2.8				
		A13	1 1/2 × 1 1/2 × 1/8	1.23	18″ 5.4	18″ 5.4	19″ 5.2	23″ 4.8	31″ 4.0	39″ 3.3	46″ 2.7	54″ 2.3					
		A15	1 1/4 × 1 1/4 × 1/8	1.01	15″ 4.5	15″ 4.4	19″ 4.0	23″ 3.6	31″ 2.9	39″ 2.3	47″ 1.8						
		A16	1 × 1 × 1/8	0.80	11″ 3.5	14″ 3.1	18″ 2.7	22″ 2.4	29″ 1.8								
EFFECTIVE LENGTH OF COLUMN - FEET					1½	2	2½	3	4	5	6	7	8	9	10	11	12

ALLOWABLE LOAD IN KIPS ON SECTIONS USED AS COLUMNS OR STUDS

UNIT STRESS – American Institute of Steel Construction - 1928 to $l/r = 200$ $(13.3 - .0385\, l/r)$ for l/r between 200 and 300.

Bracing Condition	Section	Number	Size In.	Weight per foot Lb.	1½	2	2½	3	4	5	6	7	8	9	10	11	12
					EFFECTIVE LENGTH OF COLUMN – FEET												
UNBRACED COLUMN OR STUD	UNEQUAL ANGLES	A 23	5 × 3½ × 5/16	8.7				38.4	37.7	34.2	30.8	27.5	24.4	21.7	19.3	17.2	15.4
		A 24	5 × 3 × 5/16	8.2				36.0	33.4	29.6	26.0	22.7	19.9	17.4	15.2	13.4	11.7
		A 26	4 × 3½ × 5/16	7.7				33.8	32.7	29.4	26.3	23.3	20.7	18.3	16.2	14.4	12.8
		A 27	4 × 3 × ¼	5.8				25.4	23.3	20.6	18.1	15.8	13.8	12.0	10.5	9.3	8.1
		A 28	3½ × 3 × ¼	5.4				23.4	21.2	18.7	16.3	14.1	12.3	10.7	9.3	8.2	7.0
		A 29	3½ × 2½ × ¼	4.9			21.6	20.8	18.0	15.4	13.0	11.0	9.4	8.5	6.8	5.6	4.4
		A 32	3 × 2½ × ¼	4.5			19.7	18.8	16.2	13.8	11.6	9.8	8.4	7.1	6.0	4.9	3.7
			× 3/16	3.39			15.0	14.3	12.4	10.5	8.9	7.5	6.4	5.5	4.6	3.7	2.8
		A 33	3 × 2 × 3/16	3.07		13.5	12.9	11.8	9.8	8.0	6.5	5.4	4.4	3.5	2.5	1.6	
		A 35	2½ × 2 × 3/16	2.75		12.1	11.5	10.5	8.6	7.0	5.7	4.6	3.8	2.9	2.1		
		A 48	2½ × 1½ × 3/16	2.44	10.8	10.0	8.9	7.8	6.0	4.6	3.5	2.5	1.5				
		A 37	2 × 1½ × ⅛	1.44	6.3	5.8	5.2	4.6	3.5	2.7	2.1	1.5	0.9				
		A 39	1¾ × 1¼ × ⅛	1.23	5.2	4.5	3.8	3.3	2.4	1.7	1.1						
					Loads to left of solid zig-zag line to be used for columns. Loads to left of broken zig-zag line to be used for studs in the completed structure. Loads in any part of table may be used for studs during construction.												
STUD BRACED ON MINOR AXIS AT INTERVALS GIVEN ABOVE EACH LOAD	UNEQUAL ANGLES	A 23	5 × 3½ × 5/16	8.7				38.4	45″ 38.4	45″ 38.4	45″ 38.4	45″ 38.4	45″ 38.4	50″ 36.9	56″ 35.2	62″ 33.6	67″ 31.9
		A 24	5 × 3 × 5/16	8.2				36.0	39″ 36.0	39″ 36.0	39″ 36.0	39″ 36.0	39″ 36.0	44″ 34.6	49″ 33.0	54″ 31.5	59″ 29.9
		A 26	4 × 3½ × 5/16	7.7				33.8	43″ 33.8	43″ 33.8	43″ 33.8	48″ 32.5	55″ 30.6	62″ 28.8	69″ 26.9	76″ 25.2	83″ 23.5
		A 27	4 × 3 × ¼	5.8				25.4	39″ 25.4	39″ 25.4	39″ 25.4	42″ 24.5	48″ 23.2	54″ 21.8	60″ 20.4	67″ 19.1	73″ 17.9
		A 28	3½ × 3 × ¼	5.4				23.4	37″ 23.4	37″ 23.4	40″ 22.8	47″ 21.3	54″ 19.8	61″ 18.4	68″ 17.0	74″ 15.7	81″ 14.5
		A 29	3½ × 2½ × ¼	4.9			21.6	29″ 21.6	29″ 21.6	29″ 21.6	34″ 21.1	40″ 19.7	46″ 18.4	52″ 17.1	57″ 15.8	63″ 14.6	69″ 13.5
		A 32	3 × 2½ × ¼	4.5			19.7	31″ 19.7	31″ 19.7	33″ 19.3	40″ 17.9	46″ 16.4	53″ 15.0	60″ 13.7	66″ 12.5	73″ 11.4	80″ 10.4
			× 3/16	3.39			15.0	31″ 15.0	31″ 15.0	33″ 14.7	40″ 13.6	46″ 12.5	53″ 11.5	60″ 10.5	66″ 9.5	73″ 8.7	80″ 7.9
		A 33	3 × 2 × 3/16	3.07		13.5	26″ 13.5	26″ 13.5	26″ 13.5	27″ 13.4	32″ 12.4	38″ 11.4	43″ 10.5	49″ 9.6	54″ 8.8	59″ 8.0	
		A 35	2½ × 2 × 3/16	2.75		12.1	26″ 12.1	26″ 12.1	26″ 12.1	33″ 11.0	39″ 10.0	45″ 9.0	52″ 8.0	58″ 7.2	65″ 6.4		
		A 48	2½ × 1½ × 3/16	2.44	10.8	19″ 10.8	19″ 10.8	19″ 10.8	19″ 10.8	24″ 9.9	29″ 8.9	34″ 8.0	39″ 7.2				
		A 37	2 × 1½ × ⅛	1.44	6.3	19″ 6.3	19″ 6.3	19″ 6.3	24″ 5.8	30″ 5.1	37″ 4.4	43″ 3.9	49″ 3.4				
		A 39	1¾ × 1¼ × ⅛	1.23	16″ 5.4	16″ 5.4	16″ 5.4	17″ 5.3	23″ 4.6	28″ 4.0	34″ 3.4						
EFFECTIVE LENGTH OF COLUMN – FEET					1½	2	2½	3	4	5	6	7	8	9	10	11	12

Products Used In Residence Construction

Supplementing the field of Steel Framing which forms the main subject of this booklet, the Subsidiary Companies of United States Steel Corporation manufacture many products suitable for collateral purposes in residence construction, such as materials used for Steel Lathing, Steel Parts for Windows and Doors, Tinsmithing, Steel Piping, Steel Wiring, and Steel Service Equipment; also Steel Fencing, Steel Wire Nails, Steel Reinforcement for Concrete, Steel Welding Rods and Electrodes, as well as Stainless Steel for all purposes. They also manufacture Cement and Slag for use in Concrete and Masonry construction. Complete catalogs and descriptive literature are available upon request.

A summary of both framing and collateral products is given on this and the following pages with the names of the companies producing them. In some cases the entire range is not made by all companies.

American Bridge Company Frick Building, 440 Fifth Avenue, Pittsburgh, Pa. **The Canadian Bridge Company, Limited** Walkerville, Ontario, Canada	FABRICATED STRUCTURAL STEEL For all Purposes
American Sheet and Tin Plate Company Frick Building, 440 Fifth Avenue, Pittsburgh, Pa. **Columbia Steel Company** Russ Building, 235 Montgomery Street, San Francisco, Calif. **Tennessee Coal, Iron & Railroad Company** Brown-Marx Building, 2000 First Avenue North, Birmingham, Ala.	SHEETS (Plain, Copper Steel, Black, Full Finished, Galvanized, and Terne Plate) for Expanded Metal Lath Bases, Screeds, Grounds Corner Beads for Plastering Bathroom and Kitchen Cabinets and other Equipment Air Conditioning Units Casings and Frames for Doors and Windows Metal Lumber Sections Laundry Chutes Floor Sleeper Clips Metal Tile and Pressed Steel Sinks Metal Flashing Metal Shingles Flues, Ducts, and Ventilating Equipment Gutters, Leaders, Spouts, and Drains Stoves, Ranges, and Furnaces Steel Doors Partitions and Ceilings Terne Plate Roofing Galvanized Roofing and Siding Septic Tanks and Closets STAINLESS STEEL SHEETS AND LIGHT PLATES for Decorative and Utilitarian Purposes

American Steel & Wire Company 208 South La Salle Street, Chicago, Ill.	WIRE PRODUCTS Wire Mesh and Fabric for Reinforcing Concrete Paper Back Mesh for Stucco and Plaster Wire Rope and Sash Cord Cable Nails—Bright, Coated, Galvanized, and Stainless Steel Electrodes and Rods for Fusion Welding Electric Cables and Wiring Fencing and Gates
Tennessee Coal, Iron & Railroad Company Brown-Marx Building, 2000 First Avenue North, Birmingham, Ala.	COLD ROLLED STRIP PRODUCTS for Bases, Screeds, and Grounds Moldings Corners Casings and Frames for Doors and Windows Metal Lumber Sections Floor Sleeper Clips Steel Doors Partitions HOT ROLLED SHAPES for Ornamental Fencing and Posts STAINLESS STEEL for Decorative and Utilitarian Purposes
Carnegie Steel Company Carnegie Building, 434 Fifth Avenue, Pittsburgh, Pa. **Columbia Steel Company** Russ Building, 235 Montgomery Street, San Francisco, Calif. **Illinois Steel Company** 208 South La Salle Street, Chicago, Ill. **Tennessee Coal, Iron & Railroad Company** Brown-Marx Building, 2000 First Avenue North, Birmingham, Ala.	VARIOUS PRODUCTS Structural Shapes for Framing Members—Studs, Joists, Girts, Lintels Reinforcing Bars for Concrete Foundations and Floors Plates for Battledeck Flooring Light Plates for Wall Construction Hot Rolled Strip for Metal Lumber Sections Bars and Shapes for Open Web Bar Joists Bars and Channels for Furring and Studding Bar Sections for Window Sash and Casement Blast Furnace Slag for Concrete Aggregate USS Stainless and Heat Resisting Steels
Cyclone Fence Company Waukegan, Illinois	WIRE PRODUCTS Chain Link Property Protection Fence and Gates Ornamental Lawn Fence and Gates Ornamental Iron Fence and Gates (Standard and Architectural Designs) Window Guards Wire Screen Cloth for Window and Door Screening Wire Baskets and Garden Accessories
National Tube Company Frick Building, 440 Fifth Avenue, Pittsburgh, Pa.	TUBULAR PRODUCTS National Scale-Free Pipe, Black or Galvanized, is available in standard and extra heavy weights for numerous purposes in residence construction. For those uses where the piping is exposed to alternate wet and dry conditions (atmospheric corrosion), National Black or Galvanized Copper-Steel Pipe is recommended. For particularly corrosive waters, National Duroline Pipe is recommended for both hot and cold water service lines. National USS Stainless Steel Tubing is available for inside or outside ornamental work, tubular embellishments, and kitchen equipment of a tubular nature.

Universal Atlas Cement Company 208 South La Salle Street, Chicago, Ill.	CEMENT for Concrete Foundations, Floors, Stucco, Mortar, Driveways, and Sidewalks Atlas Portland Cement Universal Portland Cement Atlas White Portland Cement Atlas Waterproofed White Portland Cement
Scully Steel Products Company 1319 Wabansia Avenue, Chicago, Illinois	WAREHOUSES AT Chicago, Ill. Cleveland, Ohio Boston, Mass. St. Louis, Mo. Pittsburgh, Pa. Newark, N. J. Baltimore, Md. St. Paul, Minn. CARRY IN STOCK STEEL FOR RESIDENCE CONSTRUCTION AS LISTED BELOW Structural Shapes: Beams Channels Angles Bars: Round Square Flat Hexagon Small Shapes: Oval Half Oval Bevel Edge Half Round Bar Channels and Angles Sheets: Blue Annealed Black Galvanized Stainless Copper Bearing Blue Annealed and Galvanized Sheets Welding Rod Bolts Nuts Rivets Washers Cold Rolled Strip Steel A Warehouse is also located at Houston, Texas, which carries products of Carnegie Steel Company and Tennessee Coal, Iron & Railroad Company. Other subsidiaries have warehouses at various points. Inquiries for material should be addressed to the district offices of the respective companies.
Columbia Steel Company Russ Building, 235 Montgomery Street, San Francisco, Calif.	WAREHOUSES AT San Francisco, Calif. Los Angeles, Calif. Portland, Oregon Seattle, Wash. Comprehensive stocks of materials suitable for use in residence construction are carried in these warehouses.
United States Steel Products Company Hudson Terminal Building, 30 Church Street, New York, N. Y.	DISTRIBUTORS FOR EXPORT of all products of the Manufacturing Subsidiaries of the United States Steel Corporation. Branch Offices, Representatives and Correspondents in many Foreign Countries.